HALEY ALDRICH

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REPORT ON

CORRECTIVE MEASURES ASSESSMENT
AREA 2 POND, AREA 3 POND, AND AREA 4 POND
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

by
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Cleveland, Ohio

for
Evergy Kansas Central, Inc.
Topeka, Kansas

File No. 129778-043
March 2021

CMA Report Overview

Evergy Kansas Central, Inc. (Evergy; f/k/a/ Westar Energy, Inc.) retained Haley & Aldrich, Inc. (Haley & Aldrich) to prepare this Corrective Measures Assessment (CMA) for the Coal Combustion Residual (CCR) units, referred to as the former Area 2 Pond, Area 3 Pond, and Area 4 Pond (collectively, Ash Ponds), herein referred to as the "Site", located at the Lawrence Energy Center (LEC). It is important to note that the LEC Ash Ponds are no longer operational, they were dewatered and the CCR waste inside the Ash Ponds has been removed (completed in 2018), and removal of the former Ash Pond berms is underway and is scheduled to be completed by the end of 2021.

The LEC is an active coal-burning electricity generating facility located along the Kansas River near Lawrence, Kansas. This CMA was completed in accordance with requirements stated in the United States Environmental Protection Agency's (USEPA) rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities,* 40 Code of federal Regulations (CFR) Parts 257 and 261 (April 17, 2015) and subsequent revisions.

Evergy implemented a groundwater monitoring program in compliance with the CCR Rule Response to Partial Vacatur[1] effective October 4, 2016 Rule published by the USEPA, as these are designated "inactive" units previously regulated by 40 CFR 257.100 (vacated). Assessment monitoring conducted in 2020 indicated the presence and concentration of Appendix IV constituents in groundwater specified in the CCR Rule. Arsenic, fluoride, lithium, and molybdenum were detected at statistically significant levels (SSL) above the Groundwater Protection Standards (GWPS) established for the Site.

An alternate source evaluation was completed in October 2020 which demonstrated that a source other than the Site caused the SSL for fluoride downgradient of the Site. The demonstration and the underlying data support the conclusion that the naturally occurring presence of fluoride, and its natural variability in groundwater is the likely source of the fluoride. As a result, fluoride is not addressed in this CMA.

Haley & Aldrich completed a detailed environmental evaluation of the Site and surrounding area in preparing this CMA. That evaluation included a risk evaluation, provided as **Appendix A**, to identify whether current groundwater conditions pose an unacceptable risk to human health and the environment, and whether corrective measures mitigate such risk, if present. **The risk evaluation concluded that there are no adverse effects on human health or the environment currently or under reasonably anticipated future uses from either surface water or groundwater due to CCR management practices at the Site.**

CMA Report Contents and Highlights

As discussed in **Section 1** of this report, Haley & Aldrich considered the following in conducting the CMA process: the presence, distribution, and geochemical behavior of the CCR SSLs (arsenic, lithium, and molybdenum) in groundwater. In addition, the nature of the CCR contents and configuration/historical operations of the Site, along with the site hydrogeologic setting, and finally the results of the detailed site-specific risk evaluation were considered holistically in performing the CMA exercise for the Site.

[1] 40 CFR Part 257 [EPA-HQ-OLEM-2016-0274; FRL-9949-44-OLEM] *Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities; Extension of Compliance Deadlines for Certain Inactive Surface Impoundments; Response to Partial Vacatur.*

Section 2 of this report provides the background for the development of a comprehensive conceptual site model (CSM) which characterizes the subsurface conditions including site geology and the uppermost groundwater flow regime at the site. The CSM was used to not only support the development of an informed CCR groundwater monitoring program for the LEC Site, but it was also fundamental to supporting the evaluation of the groundwater remedies included in the CMA process. The subsurface conditions underlying the Site consists of terrace deposits (which are Kansas River floodplain deposits) which are underlain by interbedded shale and limestone strata. The uppermost aquifer beneath the Site consists of unconsolidated alluvium (terrace deposits) with saturated thicknesses ranging from approximately 21 to 38 feet based on observations made during drilling conducted at the Site. Groundwater flow in that uppermost aquifer at the LEC is predominantly to the north/northeast (toward the Kansas River) as supported by piezometric data collected during the initial site characterization and confirmed via groundwater monitoring data collected over a period of years. Furthermore, typical seasonal changes in the river stage are not expected to dramatically affect the predominant groundwater flow (i.e., flow direction, groundwater gradient or flow velocity) in the uppermost alluvial terrace deposits that immediately underly the Site.

Section 3 of this CMA addresses the development of the site-specific risk evaluation developed to support this CMA evaluation. It is clear from the risk evaluation conducted that there are no adverse effects on human health or the environment currently or under reasonably anticipated future uses from either surface water or groundwater due to CCR management practices at the Site.

There are no downgradient users of groundwater as drinking water – thus, there is no impact on drinking water. Even for the limited results that may be above GWPS for some of the groundwater sampling events, there is no complete drinking water exposure pathway to groundwater. Where there is no exposure, there is no potential for adverse risk. Furthermore, because no adverse risk currently exists, all the remedies included in this CMA are considered protective of human health and the environment (40 CFR 257.97(b)(1)).

Following in **Section 4** of this CMA report, the CMA process is defined as specified in the CCR Rule, and a comprehensive narrative is provided which explains how the CMA process was applied for the evaluation of groundwater remedies associated with SSLs identified with the Site. To achieve a comprehensive and defensible CMA, the process includes activities and groundwater remediation alternatives (plus the closure by removal (CBR) activities for the Ash Ponds already completed by Evergy)[2] that were then combined to constitute comprehensive groundwater remedies designed to achieve the GWPS. Those comprehensive remedies include:

- Alternative 1: CBR with monitored natural attenuation (MNA) and groundwater remediation performance monitoring;
- Alternative 2: CBR with groundwater pumping and ex-situ treatment;
- Alternative 3: CBR with groundwater pumping and ex-situ treatment and barrier wall; and
- Alternative 4: CBR with in-situ groundwater treatment.

As part of the CMA process, these four groundwater alternatives were evaluated based on the remedial threshold criteria provided in the CCR rule (§257.97 (b)) and then compared to the balancing criteria

[2] As stated previously, Evergy proactively completed removal of the Area 2 and Area 3 Ash Ponds (by 2018) along with Area 4 Ash Pond (circa 2017). Therefore, only closure by removal is considered as part of the comprehensive groundwater remedies evaluated in this CMA.

stated in the CCR Rule (§257.97 (c)). These criteria are introduced below and included in their entirety in the introductory section and subsequent sections of this report:

§257.97 Selection of remedy
(b) [THRESHOLD CRITERIA] Remedies must:

(1) Be protective of human health and the environment;

(2) Attain the groundwater protection standard as specified pursuant to §257.95(h);

(3) Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment;

(4) Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems;

(5) Comply with standards for management of wastes as specified in §257.98(d).

(c) [BALANCING CRITERIA] In selecting a remedy that meets the standards of paragraph (b) of this section, the owner or operator of the CCR unit shall consider the following evaluation factors:

(1) The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful

(2) The effectiveness of the remedy in controlling the source to reduce further releases

(3) The ease or difficulty of implementing a potential remedy(s); and

(4) The degree to which community concerns are addressed by a potential remedy(s).

As stated, all groundwater remedies considered in the CMA must be capable of achieving the GWPS and satisfy the five threshold criteria cited above from the CCR Rule. Development of these remedial alternatives and their conformance with the threshold criteria are presented in narratives included in this report.

In Section 5, a comparison of the corrective measures alternatives is performed. This comparison consists of evaluating the remedial alternatives with respect to the first three balancing criteria listed above. Note that the fourth balancing criterion (which considers the degree to which community concerns are addressed), will be re-evaluated following a public meeting to be held at least 30 days prior to remedy selection (40 CFR 257.96(e)).

Section 6 presents a summary of the overall comparative process in the evaluation of corrective measures in the context of the site-specific conditions and the process defined by the CCR Rule.

This CMA, and the input received during the public meeting, and any additional nature and extent (N&E) investigation work results will be used to identify a final corrective measure (remedy) for implementation at the former LEC Ash Ponds. In addition, Section §257.97(a) of the CCR Rule requires that a semi-annual report be prepared to document progress toward remedy selection and design. Once a remedy is selected, a final remedy selection report must be prepared to document details of the selected remedy and how the selected remedy meets §257.97(b) requirements. The final selected remedy report must also be certified by a professional engineer, placed in the operating record, and posted to the Evergy CCR website.

In accordance with §257.98, Evergy will implement a groundwater monitoring program to document the effectiveness of the selected remedial alternative. Corrective measures are considered complete when monitoring reflects that the SSL constituent concentrations in groundwater downgradient of the Site do not exceed Appendix IV GWPS for three consecutive years (40 CFR 257.98(c)(2)). It should be noted that USEPA is in the process of modifying certain CCR Rule requirements and, depending upon the nature of such changes, assessments made herein could be modified or supplemented to reflect such future regulatory revisions. See *Federal Register (March 15, 2018; 83 FR 11584*).

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List of Acronyms and Abbreviations

Abbreviation	Definition
AMSL	Above Mean Sea Level
ASD	Alternate Source Demonstration
CBR	Closure by Removal
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
CMA	Corrective Measures Assessment
cm/sec	Centimeters per Second
COC	Constituent of Concern
CSM	Conceptual Site Model
Evergy	Evergy Kansas Central, Inc. (f/k/a/ Westar Energy, Inc.)
FGD	Flue Gas Desulfurization
GWPS	Groundwater Protection Standards
Haley & Aldrich	Haley & Aldrich, Inc.
KGS	Kansas Geological Survey
LEC	Lawrence Energy Center
MNA	Monitored Natural Attenuation
N&E	Nature and Extent
O&M	Operation and Maintenance
RO	Reverse Osmosis
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
SW-DAF	Surface Water Dilution and Attenuation Factor
USEPA	United States Environmental Protection Agency
WWC5	Water Well Completion Records Database

1. Introduction

Haley and Aldrich Inc. (Haley & Aldrich) was retained by Evergy Kansas Central, Inc. (Evergy; f/k/a/ Westar Energy, Inc.) to prepare this Corrective Measures Assessment (CMA) for the Coal Combustion Residual (CCR) units, referred to as the former Area 2 Pond, Area 3 Pond, and Area 4 Pond (collectively, Ash Ponds), herein referred to as the "Site", located at the Lawrence Energy Center (LEC). Haley & Aldrich conducted detailed geologic and hydrogeologic investigations under the United States Environmental Protection Agency's (USEPA) rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities,* 40 Code of Federal Regulations (CFR) Parts 257 and 261 effective October 19, 2015 including subsequent revisions (primarily the Response to Partial Vacatur revision in October 2016 requiring groundwater monitoring at the inactive impoundments). These investigations were, in part, related to the Site groundwater monitoring and corrective action requirements in the CCR Rule. It is important to note that the CCR was removed from the LEC Ash Pond sub-units (completed 2018), and removal of the former Ash Pond berms is underway and is scheduled to be completed by the end of 2021.

This CMA includes a summary of the groundwater monitoring results for the CCR Rule Appendix III and Appendix IV constituents, an evaluation of the Appendix III constituents for statistically significant increases (SSI) compared to background, and a comparison of the Appendix IV constituents detected in assessment monitoring to the Groundwater Protection Standards (GWPS). These evaluations identified statistically significant levels (SSL) above GWPS for arsenic, fluoride, lithium, and molybdenum in groundwater at multiple monitoring wells located downgradient of the Site.

An alternate source demonstration (ASD) for fluoride was completed in October 2020 for the Site; therefore, this CMA is being prepared to address arsenic, lithium, and molybdenum in groundwater. The ASD for fluoride was certified by a qualified professional engineer and a qualified professional geologist, both licensed in the State of Kansas. Documentation supporting the successful ASD, along with the professional engineer's certification has been provided in the 2020 Annual Groundwater Monitoring and Corrective Action Report as required by 40 CFR §257.95(g)(3)(ii). This CMA report evaluates potential corrective measures to remediate groundwater for the exceedance of the GWPS for arsenic, lithium, and molybdenum in groundwater.

1.1 FACILITY DESCRIPTION/BACKGROUND

The LEC former Ash Ponds are located in a light industrial area located northwest of Lawrence in Douglas County, Kansas (**Figure 1-1**). The LEC is an active energy production facility that generates electricity through coal combustion. The CCR generated are byproducts of the combustion process and include bottom ash, fly ash, economizer ash, and flue gas desulfurization (FGD) material. The fly ash and bottom ash are used beneficially or landfilled. FGD material generated at the LEC is landfilled on-site. The former Ash Ponds consisted of a series of settling ponds (sub-units) within the embanked areas that were historically used to temporarily manage CCR material, but the function of and purpose for the former Ash Ponds has been replaced by an above-ground tank system and the CCR waste has been removed from the ponds (as of 2018). The former impoundment berms for the Ash Ponds will be removed by the end of 2021.

1.2 GROUNDWATER MONITORING

Groundwater monitoring under the CCR Rule occurs through a phased approach to allow for a graduated response (i.e., baseline, detection, and assessment monitoring as applicable) and evaluation of steps to address groundwater quality. Haley & Aldrich prepared a *Network Description* (Haley & Aldrich, 2020a), a *Sampling and Analysis Plan* (Haley & Aldrich, 2020b), and a *Statistical Data Analysis Plan* (Haley & Aldrich, 2020c) as required by the CCR Rule. The Sampling and Analysis Plan and Statistical Data Analysis Plan currently in use were reviewed and approved by the Kansas Department of Health and Environment in September 2020. The documents outline the design of the groundwater monitoring system, groundwater sampling and analytical procedures, and groundwater statistical analysis methods.

The current certified multi-unit groundwater monitoring network for the Site includes one background well (MW-37) and five downgradient monitoring wells (MW-38, MW-39, MW-40, MW-K, and MW-L) located around the perimeter of the Site. This groundwater monitoring network meets the requirement criteria in the §257.91(c)(1) defining a ground water monitoring system with a minimum of one upgradient and three downgradient monitoring wells. Four monitoring wells (MW-37 through MW-40) were installed in November 2017. Monitoring wells MW-K and MW-L were installed in 1998 and were successfully evaluated for inclusion into the monitoring system. Compliance monitoring well locations are shown on **Figure 1-2.**

Groundwater monitoring associated with baseline and detection monitoring occurred in 2018 and 2019. Analytical results obtained from these sampling events were compared to background/upgradient concentrations, natural groundwater values, and used USEPA and Kansas Department of Health and Environment approved statistical methods to determine whether an SSI of Appendix III constituent concentrations had occurred downgradient of the Site at concentrations above background. The results of statistical evaluations completed in July 2019 identified SSIs of Appendix III constituents in multiple downgradient monitoring wells relative to concentrations observed at background concentrations. Accordingly, an assessment monitoring program was initiated on January 13, 2020 and respective notification of establishment of an assessment monitoring program was completed on February 12, 2020.

The first annual assessment monitoring sampling event was completed in December 2019 for all Appendix IV constituents in accordance with 40 CFR §257.95(b). Semi-annual assessment monitoring was completed in March 2020 for Appendix III and Appendix IV constituents detected during the December 2019 annual assessment monitoring sampling event as defined in 40 CFR §257.95(d)(1). The statistical evaluation completed on the March 2020 analytical data indicated that arsenic, fluoride, lithium, and molybdenum were present in groundwater at SSLs above the GWPS in downgradient wells. Appendix IV analytical results for the baseline and assessment monitoring events are summarized in **Table 1-1.**

As a result of this determination and in accordance with 40 CFR §257.95(g)(3), an alternate source evaluation was initiated. The evaluation demonstrated that a source other than the Site caused the SSL for fluoride identified downgradient of the Site. The demonstration and the underlying data support the conclusion that the naturally occurring presence of fluoride, and its natural variability in groundwater is the likely source of the fluoride.

1.3 CORRECTIVE MEASURES ASSESSMENT PROCESS

The CMA process involves assessment of groundwater remediation technologies. These remedies must meet the following threshold criteria as stated in the CCR Rule:

> §257.97 Selection of remedy [Threshold Criteria]
> (b) Remedies must:
>> (1) Be protective of human health and the environment;
>> (2) Attain the groundwater protection standard as specified pursuant to §257.95(h);
>> (3) Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment;
>> (4) Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems;
>> (5) Comply with standards for management of wastes as specified in §257.98(d).

Once these technologies are demonstrated to meet these threshold criteria, they are then compared to one another with respect to the following balancing criteria as stated in the CCR Rule:

> §257.97 Selection of remedy [Balancing Criteria]
> (c) In selecting a remedy that meets the standards of paragraph (b) of this section, the owner or operator of the CCR unit shall consider the following evaluation factors:
>> (1) The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful based on consideration of the following:
>>> (i) Magnitude of reduction of existing risks;
>>> (ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;
>>> (iii) The type and degree of long-term management required, including monitoring, operation, and maintenance;
>>> (iv) Short-term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal of contaminant;
>>> (v) Time until full protection is achieved;
>>> (vi) Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment;
>>> (vii) Long-term reliability of the engineering and institutional controls; and
>>> (viii) Potential need for replacement of the remedy.
>>
>> (2) The effectiveness of the remedy in controlling the source to reduce further releases based on consideration of the following factors:
>>> (i) The extent to which containment practices will reduce further releases; and
>>> (ii) The extent to which treatment technologies may be used.
>>
>> (3) The ease or difficulty of implementing a potential remedy(s) based on consideration of the following types of factors:
>>> (i) Degree of difficulty associated with constructing the technology;
>>> (ii) Expected operational reliability of the technologies;

(iii) Need to coordinate with and obtain necessary approvals and permits from other agencies;
(iv) Availability of necessary equipment and specialists; and
(v) Available capacity and location of needed treatment, storage, and disposal services.

(4) The degree to which community concerns are addressed by a potential remedy(s).

The fourth balancing criterion involves evaluating the degree to which community concerns regarding the proposed remedial alternatives are addressed. This criterion will be assessed by presenting the remedial alternatives at a public meeting and soliciting comments. That meeting will be held by Evergy at least 30 days prior to remedy selection.

1.4 RISK REDUCTION AND REMEDY

As presented above, the CCR Rule (§257.97(b)(1) - Selection of Remedy) requires that remedies must be protective of human health and the environment. Further, §257.97(c) of the CCR Rule requires that in selecting a remedy, the owner or operator of the CCR unit must consider specific evaluation factors, including the risk reduction achieved by each of the proposed corrective measures. Each of the balancing criteria listed here from §257.97 and discussed in **Section 5** are those that consider risk to human health or the environment including:

- (c)(1)(i) Magnitude of reduction of existing risks;
- (c)(1)(ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;
- (c)(1)(iv) Short-term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal of contaminant;
- (c)(1)(vi) Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment;

The following are additional factors related to risk that are factored into the schedule for implementing and completing remedial activities once a remedy is selected (§257.97(d)):

- (d)(4) Potential risks to human health and the environment from exposure to contamination prior to completion of the remedy[3];
- (d)(5)(i) Current and future uses of the aquifer;
- d)(5)(ii) Proximity and withdrawal rate of users; and
- (d)(5)(iv) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to CCR constituents.

[3] Factors (d)(4) and (d)(5) are not part of the CMA evaluation process as described in §257.97(d); rather they are factors the owner or operator must consider as part of the schedule for remedy implementation.

Section 3 presents a summary of the groundwater risk evaluation that provides the basis for evaluating these risk-based balancing criteria in **Section 5**.

1.5 CMA AMENDMENTS

As additional information becomes available, including future groundwater monitoring results or other site-specific or general information, or technological developments, this CMA is subject to change. Nature and extent evaluations of Appendix IV constituents above the GWPS are still underway for the site and may influence the information presented in this report, including the potential corrective measures and the analysis of the potential corrective measures. To the extent material changes to the CMA become necessary, such revised versions of the CMA will be posted to the facility CCR public website at https://www.evergy.com/ccr.

2. Groundwater Conceptual Site Model

To evaluate potential remedy options, a Conceptual Site Model (CSM) was developed and evaluated based on data collected and associated with the Site. A groundwater CSM characterizes the subsurface conditions including site geology and the uppermost groundwater flow regime at the site. More specifically the CSM is a tool used for the analyses of groundwater used to understand how water and contaminants travel beneath an area, based on hydrogeological information captured from available data. The CSM for the Site is summarized below.

2.1 SITE SETTING

Lawrence Energy Center is located in a light industrial area northwest of Lawrence in Douglas County, Kansas along the south side of the Kansas River. The facility's postal address is 1250 North 1800 Road, Lawrence, Kansas 66049. The Site is situated within the northwest quadrant of the facility. The Site boundaries are presented in **Figure 1-1**. The LEC property is bordered to the north by the Kansas River, timbered areas and private farmland; to the east by the Kansas River; to the South by County Road N1800 and private farmland; and to the west by Evergy property and private farmland. A residential area partially abuts LEC property near the southeast corner. The approximate surface elevation at the LEC ranges from approximately 820 feet above mean sea level (AMSL) to 845 AMSL.

2.2 GEOLOGY AND HYDROGEOLOGY

The LEC facility and the Site lie within an area of Pleistocene glacial activity in the Dissected Till Plains region of the Central Lowlands geomorphic province. Geologic units that underlie the Site are roughly horizontal with a regional dip northwest and consist of poorly sorted terrace deposits consisting of reworked glacial till material that includes clay, sand, gravel, and a shale member of the Tonganoxie sandstone member. The terrace deposits represent Kansas River floodplain deposits and are underlain by interbedded shale and limestone strata representing transgressions and regression of marine and near-shore depositional environments. The uppermost aquifer beneath the Site consists of unconsolidated alluvium (terrace deposits). A cross section depicting geologic units beneath the Site is included as **Figure 2-1**.

2.2.1 Unsaturated Material Overlying the Uppermost Aquifer

The terrace deposits underlying the Site are unconfined; unsaturated material above the uppermost aquifer is composed of the same terrace deposit materials (poorly sorted clay, sand, gravel, and shale) as the saturated aquifer. The thickness of the unsaturated materials observed at the Site is based on the observed static water level and corresponds to the linear distance from ground surface to the uppermost aquifer. Haley & Aldrich has made direct observation of the unsaturated material overlying the uppermost aquifer based on compliance well drilling (November 2017) and drilling conducted to define the nature and extent investigation conducted at the Site. Based on observations recorded during groundwater monitoring conducted between March 2018 and December 2020, the unsaturated material overlying the uppermost aquifer at the Site is up to 28 feet thick.

2.2.2 Uppermost Aquifer

Section §257.53 of the CCR Rule defines an aquifer as the geologic formation, group of formations, or portion of a formation capable of yielding usable quantities of groundwater to wells or springs. The uppermost aquifer is defined in §257.53 of the CCR Rule as the geologic formation nearest the natural ground surface that is an aquifer, as well as lower aquifers that are hydraulically interconnected with this aquifer within the facility boundary.

The water-bearing geologic formation nearest the natural ground surface at the Site are terrace deposits consisting of reworked glacial till material that includes poorly sorted clay, sand, and gravel. Those deposits proximate to the site have maximum thickness of approximately 55 feet and are capable of yielding groundwater to wells or springs. The saturated thickness of the uppermost aquifer beneath the Site is approximately 21 to 38 feet based on observations made during drilling conducted at the Site.

Review of the Kansas Geological Survey (KGS) Water Well Completion Records (WWC5) Database indicates that the terrace deposit aquifer may be used for water supply in the vicinity of the Site. The nearest well (well #12107) listed in the KGS WWC5 Database is a domestic well located approximately 0.6 mile to the southwest and is up gradient of the Site. Well #12107 is reported to be completed at a depth of 39 feet below ground surface and is capable of producing groundwater at a reported rate of 10 gallons per minute. There are no drinking water wells immediately downgradient of the Site, which is defined as the area between the Site and the Kansas River, a major hydrologic boundary. The terrace deposit aquifer contains sufficient water to support low yield wells and springs and sufficient water to facilitate consistent groundwater monitoring of the saturated formation directly beneath the Site and is therefore characterized as the uppermost aquifer beneath the Site.

The materials comprising the terrace deposits beneath the Site were observed directly during the November 2017 and January 2021 drilling at monitoring wells MW-37 through MW-40 and MW-101 through MW-106, respectively. The drilling, completion, and testing of these monitoring wells yielded site-specific geologic data that were used in combination with other site-specific data developed during previous characterization activities and well installation activities to determine the appropriate number, depth, and spacing of the monitoring wells at the Site. Site-specific aquifer property values describing the alluvium and associated confining units developed during past and recent characterization activities are provided below.

Based on groundwater elevations measured during groundwater sampling events between March 2018 and December 2020, the groundwater gradient in the upper aquifer unit has ranged between approximately 0.00091 to 0.0034 feet per foot and is unconfined. Groundwater flow direction is generally to the north as indicated in **Figure 2-2**, with minor variance depending on location and sampling event.

Hydraulic conductivity of the uppermost aquifer was calculated using data generated from slug tests conducted on monitoring wells installed in the terrace deposits adjacent to the Site. The hydraulic conductivity of the clay deposits range from approximately 2.0×10^{-7} centimeters per second (cm/sec) to 1.8×10^{-6} cm/sec (Black & Veatch, 2005). In comparison, the hydraulic conductivity within the sand and gravel deposits range from approximately 2.00×10^{-3} cm/sec to 4.99×10^{-2} cm/sec based on slug tests perform in November 2020. The groundwater flow rate was calculated using hydraulic conductivity values and effective porosity obtained from published sources and groundwater elevation data measured in December 2020. Based on estimates for similar material, effective porosity of the terrace deposits is estimated to be 0.2 percent (Fetter, 1980). The calculated groundwater flow velocity is estimated to range from 9 to 205 feet per year.

The nearest gauge on the Kansas River is located at Bowersock Dam approximately 4.5 miles downstream from the Site at an elevation of 799.86 feet AMSL. Flood stage at the Bowersock Dam gauge is at an elevation of 817.86 feet AMSL. During 2020, the highest crest on the Kansas River at Lawrence was 16.75 feet. The historic maximum crest was 29.90 feet in 1951. The observed groundwater elevation at the Site is approximately between 814 and 826 feet AMSL. However, the groundwater elevations do not indicate influence by the Kansas River during flood stage. Changes in river stage are not expected to affect groundwater flow direction, groundwater gradient, or flow velocity in the terrace deposit aquifer in response to typical season change conditions.

2.2.3 Confining Layer Below the Uppermost Aquifer

A shale unit of the Tonganoxie member comprises the confining unit underlying the uppermost aquifer at the Site. The top of this member is approximately 30 to 55 feet below the Site. The thickness of the shale unit of the Tonganoxie member at other drill locations at the LEC ranges is at least 55 feet. The results of packer tests conducted at the site during previous studies indicate that the hydraulic conductivity in the shale unit of the Tonganoxie member is 1×10^{-6} cm/sec. The effective porosity is estimated to be 1 percent. Based on the reported hydraulic conductivity, the shale unit of the Tonganoxie member acts as an aquitard.

The hydrogeologic characterization data for the Site described above are summarized in **Table 2-1**.

2.3 GROUNDWATER PROTECTION STANDARDS

Haley & Aldrich completed a statistical evaluation of groundwater samples using the methods and procedures outlined in the *Statistical Data Analysis Plan* (Haley & Aldrich, 2020c) to develop the site-specific GWPS for each Appendix IV constituent at the Site. Pursuant to §257.95(h), GWPS for each of the Appendix IV constituents have been set equal to the highest value of the maximum contaminant level (established under §§141.62 and 141.66), levels provided in 40 CFR §257.95(h)(2) (from regional screening levels), or background concentrations.

Groundwater results were compared to the site-specific GWPS. Based on statistical evaluations completed for the March 2020 semi-annual assessment monitoring sampling event, SSLs above the GWPS were present in downgradient monitoring wells at the Site. Monitoring well locations with SSLs and their corresponding GWPS are provided in **Table 2-2**.

Per the document *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance, March 2009,* background concentrations were updated based on statistical evaluation of analytical results collected through December 2020 for all constituents except fluoride, which was updated through March 2019. Since the GWPS for molybdenum at the Site is determined based on the background concentration, the GWPS is subject to change as additional data is collected. The GWPS for molybdenum provided in this CMA report has been updated since the initial statistically significant limit was observed on the March 2020 semi-annual assessment monitoring data.

2.4 NATURE AND EXTENT OF GROUNDWATER IMPACTS

As outlined in **Section 1.2** of this CMA, statistically significant levels of arsenic, lithium, and molybdenum were identified in various downgradient monitoring wells during assessment monitoring. An alternate source was identified for fluoride. As a result, Evergy directed Haley & Aldrich to initiate a nature and extent (N&E) investigation for arsenic, lithium, and molybdenum in 2020 as required by the CCR Rule.

An evaluation was completed to determine if historic monitoring wells installed at the LEC in 1998 could be utilized to determine the N&E of arsenic, lithium, and molybdenum groundwater impacts downgradient of the Site. Seven monitoring wells were identified and were subsequently sampled in November 2020. Analytical results indicated that arsenic and/or lithium were present at concentrations exceeding the GWPS in four monitoring wells. Molybdenum was not detected above the GWPS in the historic monitoring wells.

Four additional N&E monitoring wells (MW-101 through MW-104) were installed downgradient of the Site in January 2021 along the northern Evergy property boundary north of the Site. The N&E monitoring wells are screened in the terrace deposits of the uppermost aquifer at elevations consistent with the compliance monitoring wells at the Site. Sampling of the N&E monitoring wells, as well as sampling of historic monitoring well MW-B, was completed in early February 2021, and laboratory analytical results are pending and will be provided when available, as required by 40 CFR 257.90-257.98. N&E groundwater analytical results will be used to supplement the evaluation of the extent of groundwater impacts. The vertical extent of groundwater impacts from arsenic, lithium, and molybdenum has been defined as the base of the uppermost aquifer by the shale unit of the Tonganoxie member, which is characterized and acts as an aquitard as outlined is **Section 2.2.3**. During N&E drilling in January 2021, an attempt to collect a groundwater sample beneath the shale unit was unsuccessful, as a water-bearing geologic unit was not encountered within 100 feet below the shale.

Monitoring well locations, including historic monitoring wells and newly installed N&E monitoring wells, are shown on **Figure 2-2**.

3. Risk Assessment and Exposure Evaluation

A "Groundwater Risk Evaluation" report has been prepared by Haley & Aldrich, as a companion to this CMA document, and is presented in **Appendix A**. The purpose of the risk evaluation report is to provide the information needed to interpret the groundwater monitoring data collected and published for the LEC Site under the CCR Rule. In addition, Evergy has taken the additional step of evaluating potential groundwater-to-surface water transport and exposure pathways in the risk evaluation. Characterization of the nature and extent of constituent migration is presently ongoing at the site. Newly developed data from this effort will be incorporated into the analysis of corrective measures and may necessitate a future update of this report section.

The risk evaluation was initiated by developing a CSM to assist in identifying the potential for human or ecological exposure to constituents that may have been released to the environment. Constituents present in the Ash Ponds can be dissolved into infiltrating water (from precipitation) and those constituents may move through the subsurface and could then be present in shallow groundwater. Constituents could move with groundwater as it flows in the downgradient direction. Groundwater flow at the site is generally in the northly direction toward the Kansas River and Baldwin Creek.

Groundwater moves slowly through the rock and soils beneath the ground. Like surface water, it also moves from areas of high elevation to areas of low elevation and can discharge into adjacent surface water bodies. Any potential release of constituents to groundwater from the Site will be limited in extent by the general flow of groundwater in the northly direction towards Baldwin Creek and the Kansas River (downgradient) and will not impact surrounding areas to the east, south, and west. Groundwater does not flow from the Site to upgradient areas to the east, or south of the pond complex.

There are no on-site groundwater users at LEC. Water for plant operations is obtained from the Kansas River and potable water is provided by the municipal water utility. The KGS WWC5 database lists nine wells within a one-mile radius of the Site boundary, seven of the wells are located either northeast of the facility on the opposite side of the Kansas River or upgradient (south) of the facility, meaning that groundwater does not flow from the Site toward those wells. Two wells (one residential well and one irrigation well) are located just under one mile from the Site to the northwest. Because groundwater flows in a northerly direction toward the Kansas River in the area of the Site and cannot move beyond the Kansas River, groundwater does not flow from the Site towards those wells. Thus, there are no downgradient groundwater users.

In order to answer the question, "Are the constituent concentrations high enough to potentially exert a toxic effect?" health risk-based screening levels were used for comparison to the downgradient monitoring wells data. Of the groundwater data collected, the majority (84 percent) are below GWPS (i.e., below drinking water standards). Even for the very few results that are above screening values for some of the groundwater sampling events, there are no on-site or downgradient groundwater users. Where there is no current or reasonably anticipated future drinking water exposure, there is no risk.

Depth to groundwater in the area of the Site ranges from approximately 8 feet to greater than 20 feet. Since groundwater in some areas is shallow (less than 10 feet deep), construction workers at LEC performing intrusive excavation activities in the future could potentially contact groundwater during a short-term construction/excavation event. While this would be unlikely since heavy equipment is used for such work, the nature of this contact with groundwater has been assumed for discussion and evaluation purposes; such contact would be incidental (e.g., getting groundwater on the hands and arms). Risk-based screening levels for groundwater were developed to be protective of incidental contact by construction workers. All monitoring well analytical results are below screening levels developed for the construction worker scenario. Therefore, there is no unacceptable health risk for construction workers who could potentially contact groundwater while performing intrusive excavation activities.

LEC is located on the Kansas River – a major river system with a large and rapid river flow. The Kansas River is a supply source for drinking water and can be used for human recreation – wading, swimming, boating, fishing. The river also serves as habitat for ecological receptors (aquatic species such as fish, amphibians, etc.). In order to evaluate the concentration level at which groundwater entering the river system may pose a potential human health or ecological risk, a groundwater to surface water dilution and attenuation factor (SW-DAF) was derived for groundwater that may flow to the Kansas River; the conservatively calculated by Haley and Aldrich) SW-DAF is 1,026 (a unitless value) as presented in **Appendix A**.

The SW-DAF for the Kansas River is applied to the lowest conservative risk-based screening level for surface water (including screening levels for both human health and ecological receptors) to calculate a groundwater concentration that is protective of Kansas River uses. The results indicate that groundwater concentrations at the Site would not cause a CCR-related constituent in Kansas River surface water to be above a screening level protective of people who use the Kansas River as a source of drinking water and for recreational purposes, and for ecological receptors that live in or use the Kansas River.

It was assumed that the small size and periodic drying of Baldwin Creek would limit its ability to support a consumptive fishery or habitat for aquatic species and limit its recreational use mostly to wading. Evaluating recreational use of Baldwin Creek is conservative because the portion of Baldwin Creek adjacent to the Site passes through Evergy property, therefore, it is unlikely that recreational activities would occur in the adjacent creek.

A SW-DAF was not calculated for groundwater that may flow to Baldwin Creek due to the very low flow of the creek, therefore, concentrations in the Site monitoring wells were compared directly to conservative risk-based screening levels for a recreational wader scenario. This is a conservative estimate of the potential risk associated with recreational wader exposure to surface water in Baldwin Creek as it is assumed that the actual condition in Baldwin Creek even under low flow conditions would exhibit lower concentrations and, therefore, be even more protective of human health and the environment. All monitoring well analytical results are below human health recreational wader screening levels for Baldwin Creek. Therefore, there is no unacceptable health risk for recreational receptors who could potentially contact surface water while wading.

This evaluation demonstrates that there are no adverse impacts on human health or ecological receptors from constituents present in groundwater resulting from coal ash management practices at the Site. Therefore, because no adverse risk currently exists, any of the remedies considered in this CMA are all protective of human health and the environment, and implementation of any of the remedial alternatives will not result in a meaningful reduction in risk to groundwater-related exposures or risk.

4. Corrective Measures Alternatives

4.1 CORRECTIVE MEASURES ASSESSMENT GOALS

As noted in §257.96(a), within 90 days of detecting Appendix IV SSLs, "the owner or operator must initiate an assessment of corrective measures to prevent further releases, to remediate any releases and to restore affected area to original conditions". The corrective measures evaluation that is discussed below and in subsequent sections provides an analysis of the effectiveness of four potential corrective measures in meeting the requirements and objectives of remedies as described under §257.97 (also shown graphically on **Figure 4-1**). Additional remedial alternatives were considered but were determined to not be viable for remediating groundwater at the Site. This assessment also meets the requirements promulgated in §257.96 for the balancing criteria (provided in more detail in **Section 1.3**) which require the assessment to evaluate:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination;
- The time required to begin and complete the remedy; and
- The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s).

The criteria listed above are included in the balancing criteria considered during the corrective measures evaluation, described in **Section 5**.

4.2 GROUNDWATER FATE AND TRANSPORT MODELING

Groundwater at the LEC was modeled using Groundwater Vistas Version 8 for flow and solute transport. The model was constructed, calibrated, and subsequent simulations run to evaluate remedy alternatives for Appendix IV constituents above the GWPS. Site-specific parameters (such as groundwater elevations and hydraulic conductivity) were utilized for model preparation. MODFLOW 2005, a finite difference three-dimensional solver, was utilized for groundwater flow estimation. Modeled groundwater elevations were compared to observed values from the on-site well network to confirm modeled performance, which achieved a calibration of less than 10 percent scaled root mean square of measured water levels, which is within typical industry standards for such models. Once groundwater flow was calibrated in the model, solute transport was completed using MT3DMS, a three-dimensional solute transport modeling program. Parameters affecting transport such as advection, diffusion, dispersion, and adsorption are utilized within the MT3DMS package to estimate solute transport within the model domain.

The calibrated flow models were used to simulate the different remediation alternatives and the effects they have on groundwater quality through time. These simulations are incorporated into the discussion on remediation alternatives provided below.

4.3 CORRECTIVE MEASURES ALTERNATIVES

Corrective measures can terminate when groundwater impacted by the Site no longer exceed the Appendix IV GWPS for three consecutive years of groundwater monitoring (§257.98(c)(2)). In accordance with §257.97, the groundwater corrective measures to be considered must meet, at a minimum, the following threshold criteria:

1. Be protective of human health and the environment;
2. Attain the GWPS as specified pursuant to §257.95(h);
3. Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment;
4. Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
5. Comply with standards for management of wastes as specified in §257.98(d).

Each of the corrective measures alternatives assembled as part of this CMA meet the requirements of the threshold criteria listed above.

The corrective measures alternatives presented below include closure by removal (CBR) of the Ash Ponds since CCR removal is actively being completed by Evergy.

4.3.1 Alternative 1 – Closure by Removal with Monitored Natural Attenuation and Remediation Performance Monitoring

Since CCR material has been removed from the Ash Pond sub-units and the berms are being removed, this alternative includes monitored natural attenuation (MNA) and performance monitoring of arsenic, lithium, and molybdenum in groundwater. With the source removed, the concentration of constituents of concern (COCs) in downgradient groundwater would decline and overall groundwater concentrations of COCs would be addressed through the processes of natural attenuation.

MNA is a viable remedial technology recognized by both state and federal regulators that is applicable to inorganic compounds in groundwater. The USEPA defines MNA as "the reliance on natural attenuation processes to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods". The 'natural attenuation processes' that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes could include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants" (USEPA, 2015). MNA can reduce concentrations of arsenic, lithium, and molybdenum in groundwater at the boundary of the Site. Long-term, Evergy would perform post-closure care activities that includes groundwater sampling as a means for performance monitoring.

4.3.2 Alternative 2 – Closure by Removal with Groundwater Pumping and Ex-Situ Treatment

Under this alternative, arsenic, lithium, and molybdenum detected at the boundary of the Ash Pond at concentrations above the GWPS would be addressed with hydraulic containment through groundwater pumping to hydraulically control the migration of those residual constituents downgradient. Pumping would be limited to the uppermost aquifer. Pumping well effluent would be treated ex-situ, likely with an ion exchange or a reverse osmosis (RO) treatment system which would be capable of treating all three constituents to acceptable levels. Both systems would have ongoing operation and maintenance (O&M), energy requirements which create a carbon footprint, and would generate a secondary waste stream – including regeneration/replacement of the ion exchange media or accumulation of reject water from the RO system.

The design and construction of an ion exchange or RO system would require additional development of a treatment system enclosure, equipment and space that adds complexity to this alternative. Implementation of a large-scale hydraulic containment system would require a detailed and lengthy design effort. Pilot testing, such as pumping tests and additional groundwater modeling, will be needed to verify the hydraulic capture zone.

Following the installation of the groundwater pumping well network, and ex-situ treatment system, Evergy would implement post-closure care activities that includes O&M of the hydraulic containment system and long-term groundwater sampling to monitor hydraulic containment system performance. Once concentrations of Appendix IV constituents downgradient of the pumping wells decrease to the GWPS, operation of the hydraulic containment system would cease.

4.3.3 Alternative 3 – Closure by Removal with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall

Similar to Alternative 2, arsenic, lithium, and molybdenum detected at the boundary of the Site at concentrations above the GWPS would be addressed with hydraulic containment through groundwater pumping to hydraulically control the migration of those residual constituents downgradient. Pumping would be limited to the uppermost aquifer. Pumping well effluent would be treated ex-situ, likely with an ion exchange or RO treatment system, which would be capable of treating all three constituents to acceptable levels. Both systems would have ongoing O&M, energy requirements which create a carbon footprint, and would generate a secondary waste stream – including regeneration/replacement of the ion exchange media or accumulation of reject water from the RO system.

To improve efficiency of the pumping wells, a low permeability subsurface barrier wall would be installed downgradient from pumping wells, along the northern and partial western boundary of the Site. The low permeability barrier wall would limit the amount of groundwater entering the pumping wells from the north and west, therefore allowing the pumping wells to operate at a lower pumping rate to achieve hydraulic containment. Appendix IV constituents already present in groundwater downgradient from the barrier wall would be addressed through processes of natural attenuation.

For ex-situ groundwater treatment, the design and construction of an ion exchange or RO system would require additional development of a treatment system enclosure, equipment and space that adds complexity to this alternative. As noted in the previous option, implementation of a large-scale hydraulic containment system would require a detailed and lengthy design effort. Pilot testing, such as pumping tests and additional groundwater modeling, will be needed to verify the hydraulic capture zone. The barrier wall would also require a significant design and construction effort.

Following the installation of the barrier wall, groundwater pumping well network, and ex-situ treatment system, Evergy would implement post-closure care activities that includes O&M of the hydraulic containment system and long-term groundwater sampling to monitor hydraulic containment system performance. Once concentrations of Appendix IV constituents downgradient of the barrier wall decrease to the GWPS, operation of the hydraulic containment system would cease.

4.3.4 Alternative 4 – Closure by Removal with In-Situ Groundwater Treatment

Under this alternative, arsenic would be addressed through the installation and operation of an in-situ treatment system, likely air sparging, downgradient of the Site with the objective of accelerating the time required to achieve the GWPS for arsenic within the treatment zone. Preliminary evaluation of groundwater conditions indicates that in-situ treatment of lithium and molybdenum is not viable; in-situ treatment would only address arsenic. Therefore, lithium and molybdenum would be addressed through MNA, as described under Alternative 1. For the in-situ treatment system, approvals and permitting would be required for the construction and injection/application of amendments (likely oxygen) to the subsurface.

Implementation of an in-situ treatment system will require a detailed and lengthy design effort with additional bench scale testing to verify groundwater treatment. The bench scale testing will evaluate the efficacy of treating arsenic in-situ, while factoring in potential changes in groundwater geochemistry which may adversely affect the stability of other CCR-related constituents.

For lithium and molybdenum, MNA is a viable remedial technology recognized by both state and federal regulators that is applicable to inorganic compounds in groundwater. The USEPA defines MNA as "the reliance on natural attenuation processes to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods". The 'natural attenuation processes' that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants" (USEPA, 2015).

Following the installation of the in-situ treatment system, Evergy would implement post-closure care activities. Post-closure care would include operation of the in-situ treatment system, long-term groundwater sampling to monitor treatment system performance for arsenic, and groundwater sampling to confirm long-term natural attenuation of lithium and molybdenum.

5. Comparison of Corrective Measures Alternatives

The purpose of this section is to evaluate, compare, and rank the four corrective measures alternatives using the balancing criteria described in §257.97.

5.1 EVALUATION CRITERIA

In accordance with §257.97(c), remedial alternatives that satisfy the threshold criteria are compared to four balancing (evaluation) criteria. The balancing criteria allow a comparative analysis for each corrective measure, thereby providing the basis for final corrective measure selection. The four balancing criteria include the following (provided in more detail in **Section 1.3**):

1. The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful;
2. The effectiveness of the remedy in controlling the source to reduce further releases;
3. The ease or difficulty of implementing a potential remedy(s); and
4. The degree to which community concerns are addressed by a potential remedy(s).

The degree to which community concerns are addressed by the potential remedies will be considered following a public meeting to discuss the results of the corrective measures assessment with interested and affected parties and will be held at least 30 days prior to remedy selection in accordance with 257.96(e).

This assessment includes an analysis of the effectiveness of potential corrective measures in meeting the requirements and objectives of the remedy as described under 257.97 while addressing the three criteria listed under 257.96(c). The three criteria listed under 257.96(c) are addressed by the specific balancing criteria summarized below and are discussed in the referenced report sections:

257.96(c) Criteria	Associated 257.97(c) Balancing Criteria	CMA Report Section
(1) The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination	257.97(c)(1)(i)	Section 5.2.1.1
	257.97(c)(1)(ii)	Section 5.2.1.2
	257.97(c)(1)(iii)	Section 5.2.1.3
	257.97(c)(1)(iv)	Section 5.2.1.4
	257.97(c)(1)(vi)	Section 5.2.1.6
	257.97(c)(1)(vii)	Section 5.2.1.7
	257.97(c)(1)(viii)	Section 5.2.1.8
	257.97(c)(2)(i)	Section 5.2.2.1
	257.97(c)(2)(ii)	Section 5.2.2.2
	257.97(c)(3)(i)	Section 5.2.3.1
	257.97(c)(3)(ii)	Section 5.2.3.2
	257.97(c)(3)(iii)	Section 5.2.3.3
	257.97(c)(3)(iv)	Section 5.2.3.4
	257.97(c)(3)(v)	Section 5.2.3.5

(2) The time required to begin and complete the remedy	257.97(c)(1)(v)	Section 5.2.1.5
(3) The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy(s)	257.97(c)(3)(iii)	Section 5.2.3.3

5.2 COMPARISON OF ALTERNATIVES

This section compares the alternatives based on evaluation of the balancing criteria listed above, as required and listed in 40 CFR 257.97(c). Each of the balancing criteria consists of several sub criteria listed in the CCR Rule (provided in more detail in **Section 1.3**), which have been considered in this assessment. The goal of this analysis is to evaluate the alternatives based on whether each is technologically feasible, relevant and readily implementable, provide adequate protection to human health and the environment, and minimizes impacts to the community as compared to the other alternatives. A summary of the remedial alternatives is provided in **Table 5-1**.

A graphic is provided within each subsection below to provide a visual snapshot of the favorability of each alternative, where green represents “most favorable”, yellow represents “less favorable”, and red represents “least favorable.”

5.2.1 Balancing Criterion 1 – The Long- and Short-Term Effectiveness and Protectiveness of the Potential Remedy, along with the Degree of Certainty that the Remedy Will Prove Successful

This balancing criterion takes into consideration the following sub criteria relative to the long-term and short-term effectiveness of the remedy, along with the anticipated success of the remedy.

5.2.1.1 Magnitude of reduction of existing risks

As indicated by the risk evaluation presented in **Section 3**, no unacceptable risk to human health and the environment exists with respect to the Site. Since the CCR material has been removed from the Ash Ponds, there is no potential for additional risk from further removal or regrading. Therefore, none of the remedial alternatives are necessary to reduce risks because no such unacceptable risk from arsenic, lithium, or molybdenum in groundwater currently exists. All four alternatives are considered favorable for this criterion.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 1 - Subcriteria i) Magnitude of reduction of risks	(green)	(green)	(green)	(green)

5.2.1.2 *Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy*

All alternatives are considered favorable since CCR material has already been removed from the Ash Ponds at LEC. No residual risk for a further release due to CCR remaining following implementation of the groundwater remedy exists.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 1 - Subcriteria ii) Magnitude of residual risk in terms of likelihood of further release	(green)	(green)	(green)	(green)

5.2.1.3 *The type and degree of long-term management required, including monitoring, operation, and maintenance*

Alternative 1 (CBR with MNA) is the most favorable alternative with respect to this criterion because it requires the least amount of long-term management and involves no mechanical systems as part of the remedy. Alternative 4 (CBR with In-Situ Treatment) is considered less favorable since the in-situ treatment system will require long-term monitoring and maintenance. Alternatives 2 and 3, which both include hydraulic containment, require long-term O&M of the pumping and ex-situ treatment system, and management of a secondary waste stream, are considered the least favorable when compared to the other alternatives. When compared to the other alternatives, Alternatives 2 and 3 also have the greatest carbon footprint due to the energy required to operate the pumping wells and ex-situ treatment system.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 1 - Subcriteria iii) Type and degree of long-term management required	(green)	(red)	(red)	(yellow)

5.2.1.4 *Short-term risks that might be posed to the community or the environment during implementation of such a remedy*

Community impacts include general impacts to the community due to increased truck traffic on public roads during construction of the remedies. Alternative 3 (CBR with hydraulic containment and barrier wall) and Alternative 4 (CBR with in-situ treatment) are considered less favorable since both alternatives will require construction beyond what is anticipated for Alternatives 1 and 2. For Alternative 3, the barrier wall construction will likely require off-site disposal of excavated soils and import of low-permeability material over local roadways. Similarly, Alternative 4 will require additional material disposal and import to create the in-situ treatment system, which is anticipated to be a series of closely spaced injection points. Minimal disturbance is anticipated with Alternative 1 (CBR and MNA) and

Alternative 2 (CBR with hydraulic containment), therefore these two alternatives are considered the most favorable.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 1 - Subcriteria iv) Short term risk to community or environment during implementation				

5.2.1.5 Time until full protection is achieved

As previously stated, there is currently no unacceptable exposure to groundwater that was impacted by arsenic, lithium, and molybdenum associated with the Site; therefore, protection is already achieved. The timeframes to achieve GWPS were evaluated using a predictive model as described in **Section 4.2**. Based upon predictive modeling, Alternatives 2 and 3, which include hydraulic containment, are predicted to achieve the GWPS in the shortest amount of time. Alternative 4 (CBR with in-situ treatment) is predicted to take more time to achieve GWPS since no active groundwater pumping is included with this alternative. Therefore, Alternative 4 is considered less favorable when compared to Alternatives 2 and 3. Alternative 1 (CBR with MNA) is predicted to take the longest amount of time to achieve the GWPS, therefore this alternative is considered the least favorable.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 1 - Subcriteria v) Time until full protection is achieved				

5.2.1.6 Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment

Alternative 1 (CBR with MNA) and Alternative 4 (CBR with in-situ treatment) are considered the most favorable since the CCR material has already been removed and potential exposure through contact with groundwater is minimal. Alternatives 2 and 3 both include hydraulic containment, which will require ongoing management and disposal of a waste stream generated by the ex-situ treatment system. Therefore, Alternatives 2 and 3 are considered less favorable when compared to the other two alternatives.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 1 - Subcriteria vi) Potential for exposure of humans and environmental receptors to remaining wastes				

5.2.1.7 Long-term reliability of the engineering and institutional controls

Alternative 1 (CBR with MNA) is expected to have high long-term reliability and is considered most favorable with respect to this criterion. The alternatives that include hydraulic containment (Alternatives 2 and 3) are considered reliable, proven technologies and would have high long-term reliability, but require field pilot studies and bench scale testing and rely on mechanical systems (groundwater pumping and treatment systems) to operate and maintain and are therefore considered less reliable. Alternative 4 (CBR with in-situ treatment) is considered the least favorable since this remedy would also require extensive field pilot studies and bench scale testing, rely on mechanical systems (oxygen injection) to operate and maintain, and would potentially be vulnerable to subsurface reliability issues such as injection point fouling and unknown preferential pathways. Therefore, Alternative 4 is considered the least favorable when compared to the other alternatives.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 1 - Subcriteria vii) Long-term reliability of engineering and institutional controls				

5.2.1.8 Potential need for replacement of the remedy

Alternative 1, which incorporates closure by removal with MNA is considered the remedy with the lowest likelihood of requiring replacement because source removal is complete, permanent, and natural processes will remedy groundwater. From the perspective of needing to replace the remedy, the alternatives that rely on ex-situ treatment systems (Alternatives 2 and 3) are considered more likely to require replacement and are therefore considered less favorable than Alternative 1. Alternative 4, which relies on in-situ treatment to address arsenic, is considered least favorable since the ability to treat groundwater is vulnerable to changes in groundwater flow direction and chemistry, development of preferential pathways/short-circuiting, and in-situ injection may create geochemical conditions that promote the mobilization or remobilization of other CCR constituents in groundwater.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 1 - Subcriteria viii) Potential need for replacement of the remedy				

5.2.1.9 Long- and short-term effectiveness and protectiveness criterion summary

The following graphic provides a summary of the long- and short-term effectiveness and protectiveness of the potential remedy, along with the degree of certainty that the remedy will prove successful. The favorability color assignments are a compilation of those assigned for subcriteria described in Sections 5.2.1.1 through 5.2.1.8. Alternative 1 (CBR with MNA) is considered favorable, while Alternative 2 (CBR with hydraulic containment) and Alternative 3 (CBR with hydraulic containment and barrier wall) are considered less favorable. Alternative 4 (CBR with in-situ treatment) is considered the least favorable.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
CATEGORY 1 Long- and Short Term Effectiveness, Protectiveness, and Certainty of Success				

5.2.2 Balancing Criterion 2 – The Effectiveness of the Remedy in Controlling the Source to Reduce Further Releases

This balancing criterion takes into consideration the ability of the remedy to control a future release, and the extensiveness of treatment technologies that will be required.

5.2.2.1 The extent to which containment practices will reduce further releases

All alternatives are considered favorable since CCR waste material has already been removed from inside the Ash Ponds (completed by 2018) and removal of the former Ash Pond berms is underway and is scheduled to be completed by the end of 2021. Since the source material inside the Ash Ponds has been removed, there is no potential for further releases.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 2 - Subcriteria i) Extent to which containment practices will reduce further releases				

5.2.2.2 The extent to which treatment technologies may be used

With respect to Alternative 1, no groundwater treatment technologies, other than natural attenuation will be used and is considered the most favorable with respect to this criterion since this is the least extensive treatment option. Alternative 2 relies on more extensive hydraulic containment with ex-situ treatment while Alternative 4 relies on in-situ treatment, therefore these two alternatives are considered less favorable when compared to Alternative 1 since they both rely on additional treatment technologies. Alternative 3 relies on hydraulic containment with ex-situ treatment with the addition of a subsurface barrier wall, another treatment technology, and is considered the least favorable when compared to the other alternatives.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 2 - Subcriteria ii) Extent to which treatment technologies may be used				

5.2.2.3 Effectiveness of the remedy in controlling the source to reduce further releases summary

The graphic below provides a summary of the effectiveness of the remedial alternatives to control the source to reduce further releases. The favorability color assignments are a compilation of those assigned for subcriteria described in Sections 5.2.2.1 through 5.2.2.2. With respect to source control, all alternatives are considered equally favorable since CCR material is being removed. With respect to controlling the CCR constituents in groundwater, Alternative 1 (CBR with MNA) is considered favorable, while Alternative 2 (CBR with hydraulic containment) and Alternative 4 (CBR with in-situ treatment) are considered less favorable since these two alternatives rely on additional remedial technology (hydraulic containment and in-situ treatment, respectively). Alternative 3 (CBR with hydraulic containment and barrier wall) is considered the least favorable when compared to the other alternatives since this alternative relies on a subsurface barrier wall in addition to the hydraulic containment system with treatment.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
CATEGORY 2 Effectiveness in controlling the source to reduce further releases				

5.2.3 Balancing Criterion 3 – The Ease or Difficulty of Implementing a Potential Remedy

This balancing criterion takes into consideration technical and logistical challenges required to implement a remedy, including practical considerations such as equipment availability and disposal facility capacity.

5.2.3.1 Degree of difficulty associated with constructing the technology

Alternative 1 (CBR with MNA) is considered favorable since removal is complete and implementation of long-term monitoring is straightforward. Alternative 2, which includes hydraulic containment with ex-situ treatment, is considered less favorable since the hydraulic containment system and ex-situ treatment will require additional treatability testing and field pilot studies, as will Alternative 4 (CBR with in-situ treatment) which is also considered less favorable. Alternative 3, which combines hydraulic containment with a barrier wall, is considered the least favorable since barrier wall construction will require additional design and permitting and may be difficult to install down to the aquitard due to existing subsurface infrastructure and the heterogenous nature of the subsurface (poorly sorted clay, sand, gravel and shale).

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	Alternative 2 CBR with Groundwater Pumping and Ex-Situ Treatment	Alternative 3 CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	Alternative 4 CBR with In-Situ Groundwater Treatment
Category 3 - Subcriteria i) Degree of difficulty associated with constructing the technology				

5.2.3.2 Expected operational reliability of the technologies

Alternative 1 (CBR with MNA) is considered the most favorable from an operational perspective because removal is being completed and MNA has a proven track record and only requires long-term monitoring following implementation. While Alternatives 2 and 3 which include hydraulic containment are also expected to be reliable, these alternatives will utilize pumping of wells, associated piping, and ex-situ treatment system with ongoing O&M. Alternative 3 is considered less favorable when compared to Alternative 1. Since the barrier wall included under Alternative 3 is expected to improve the pumping efficiency of the hydraulic containment system, Alternative 2 (which does not include a barrier wall) is considered the least favorable due to the additional pumping demands that will be present without a barrier wall. Alternative 4 (CBR with in-situ treatment) will include the long-term operation of an in-situ treatment system and further rely on mechanical systems and is therefore considered less favorable from a reliability standpoint when compared to Alternative 1.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	Alternative 2 CBR with Groundwater Pumping and Ex-Situ Treatment	Alternative 3 CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	Alternative 4 CBR with In-Situ Groundwater Treatment
Category 3 - Subcriteria ii) Expected operational reliability of the technologies				

5.2.3.3 Need to coordinate with and obtain necessary approvals and permits from other agencies

Alternative 1 (CBR with MNA) is the most favorable since CCR removal is being completed and the implementation of the MNA remedy for groundwater is straightforward. The remaining alternatives will require additional permitting and approvals for treatability testing, field scale pilot testing, groundwater discharge, groundwater treatment, and/or disposal of secondary waste streams. Alternative 3 is considered the least favorable since additional permitting and approvals will be necessary for the large-scale construction anticipated for installing the subsurface barrier wall.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	Alternative 2 CBR with Groundwater Pumping and Ex-Situ Treatment	Alternative 3 CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	Alternative 4 CBR with In-Situ Groundwater Treatment
Category 3 - Subcriteria iii) Need to coordinate with and obtain necessary approvals and permits from other agencies				

5.2.3.4 *Availability of necessary equipment and specialists*

Alternative 1 (CBR with MNA) is favorable since specialty equipment and technical specialists will not be required to implement the MNA remedy and removal of the CCR material is nearly complete. Alternative 2 will require equipment for drilling, recovery well installation, construction of groundwater conveyance systems, and an ex-situ treatment system is considered slightly less favorable since qualified contractors and equipment required should not present a great challenge, but pilot testing and bench scale testing will be required to confirm treatment. In addition to hydraulic containment, Alternative 3 incorporates a subsurface barrier wall and is considered the least favorable since specialty contractors and very large trenching equipment will be needed to complete the installation. Alternative 4 is also considered the least favorable since specialists will be required to pilot test, design, and implement the in-situ treatment system for arsenic while not altering the existing subsurface geochemical conditions which are currently favorable for the natural attenuation of lithium and molybdenum.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 3 - Subcriteria iv) Availability of necessary equipment and specialists				

5.2.3.5 *Available capacity and location of needed treatment, storage, and disposal services*

Alternative 1 is considered favorable since removal is nearly complete and no additional treatment, storage, or disposal services are anticipated. Alternatives 2 and 3 are considered less favorable since they both include ex-situ treatment which will generate a more concentrated waste stream which will require off-site transportation and treatment/disposal during operation. Alternative 4 (CBR with in-situ treatment) is considered favorable since treatment will be in-situ and no additional waste streams will be generated.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
Category 3 - Subcriteria v) Available capacity and location of needed treatment, storage, and disposal services				

5.2.3.6 *Ease or difficulty of implementation summary*

The graphic below provides a summary of the ease or difficulty that will be needed to implement each alternative. The favorability color assignments are a compilation of those assigned for subcriteria described in Sections 5.2.3.1 through 5.2.3.5. Alternative 1 (CBR with MNA) is considered the most favorable, while Alternative 2 (CBR with hydraulic containment) and Alternative 4 (CBR with in-situ treatment) are considered less favorable. Alternative 3, which includes hydraulic containment, in-situ treatment, and construction of a subsurface barrier wall, is considered the least favorable.

	Alternative 1 CBR with MNA and Remediation Performance Monitoring	**Alternative 2** CBR with Groundwater Pumping and Ex-Situ Treatment	**Alternative 3** CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	**Alternative 4** CBR with In-Situ Groundwater Treatment
CATEGORY 3 Ease of implementation				

6. Summary

This Corrective Measures Assessment has evaluated the following alternatives:

- <u>Alternative 1</u>: CBR with MNA and remediation performance monitoring;
- <u>Alternative 2</u>: CBR with groundwater pumping and ex-situ treatment;
- <u>Alternative 3</u>: CBR with groundwater pumping and ex-situ treatment and barrier wall; and
- <u>Alternative 4</u>: CBR with in-situ groundwater treatment.

In accordance with §257.97(b), each of these alternatives has been confirmed to meet the following threshold criteria:

- Be protective of human health and the environment;
- Attain the GWPS as specified pursuant to §257.95(h);
- Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV to this part into the environment;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
- Comply with standards for management of wastes as specified in §257.98(d).

In addition, in accordance with §257.97(c), each of the alternatives has been evaluated in the context of the following balancing criteria:

- The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful;
- The effectiveness of the remedy in controlling the source to reduce further releases;
- The ease or difficulty of implementing a potential remedy(s); and
- The degree to which community concerns are addressed by a potential remedy(s).

This Corrective Measures Assessment, and the input received during the public meeting, and any additional N&E investigation work results will be used to identify a final corrective measure (remedy) for implementation at the Site. §257.97(a) requires that a semi-annual report be prepared to document progress toward remedy selection and design. Once a remedy is selected, a final remedy selection report must be prepared to document details of the selected remedy and how the selected remedy meets §257.97(b) requirements. The final selected remedy report must also be certified by a professional engineer, placed in the operating record and posted to the Evergy CCR website.

References

1. USEPA. 2015a. Final Rule: Disposal of Coal Combustion Residuals (CCRs) for Electric Utilities. 80 FR 21301-21501. U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.govinfo.gov/content/pkg/FR-2015-04-17/pdf/2015-00257.pdf

2. USEPA. 2015b. Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites.

3. USEPA. 2018a. USEPA Regional Screening Levels. November 2018, values for tap water. U.S. Environmental Protection Agency. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

4. Black & Veatch, 2005. Phase II Hydrogeologic Site Investigation, Volume 1. January.

5. Haley & Aldrich, 2020a. CCR Groundwater Monitoring Network Description, Lawrence Energy Center, Lawrence, Kansas. November 24.

6. Haley & Aldrich, 2020b. Groundwater Sampling and Analysis Plan, Lawrence Energy Center, Lawrence, Kansas. August 21.

7. Haley & Aldrich, 2020c. Statistical Data Analysis Plan, Lawrence Energy Center, Lawrence, Kansas. August.

TABLES

TABLE 1-1
SUMMARY OF ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Location Group	Upgradient											
Location	MW-37	MW-37	MW-37	MW-37	MW-37	MW-37	MW-37	MW-37	MW-37	MW-37	MW-37	MW-37
Measure Point (TOC)	833.29	833.29	833.29	833.29	833.29	833.29	833.29	833.29	833.29	833.29	833.29	833.29
Sample Name	MW-37-030718	MW-37-050918	MW-37-070218	MW-37-081418	MW-37-100318	MW-37-111918	MW-37-011119	MW-37-031819	MW-37-120619	MW-37-031020	MW-37-091520	MW-37-120120
Sample Date	03/07/2018	05/09/2018	07/02/2018	08/14/2018	10/03/2018	11/19/2018	01/11/2019	03/18/2019	12/06/2019	03/10/2020	9/15/2020	12/1/2020
Depth to Water (ft btoc)	10.04	11.10	12.32	14.38	14.54	11.39	8.51	7.33	9.61	6.68	11.60	13.36
Temperature, Field (Deg C)	12.94	15.75	16.93	16.62	17.70	13.63	12.69	13.28	13.26	8.83	17.46	14.91
Conductivity (µS/cm)	936	1017	924	934	965	926	929	1022	1073	929	1260	1200
Turbidity (NTU)	0.59	2.71	1.83	0.56	0.27	0.80	18.2	10.79	1.61	5.22	0.0	0.0
Antimony, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Arsenic, Total (mg/L)	**0.0047**	**0.0077**	**0.0056**	**0.0045**	**0.0053**	**0.0054**	**0.0089**	**0.0074**	**0.0078**	**0.0065**	**0.0086**	**0.0045**
Barium, Total (mg/L)	**0.045**	**0.055**	**0.048**	**0.046**	**0.050**	**0.051**	**0.058**	**0.054**	**0.061**	**0.065**	**0.079**	**0.070**
Beryllium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Cadmium, Total (mg/L)	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	-	-	< 0.00050
Chromium, Total (mg/L)	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	-	-	< 0.0050
Cobalt, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Fluoride (mg/L)	**0.37**	**0.36**	**0.36**	**0.41**	**0.32**	**0.44**	**0.28**	**0.38**	**0.27**	**0.27**	< 0.20	< 0.20
Lead, Total (mg/L)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	-	-	< 0.010
Lithium, Total (mg/L)	**0.013**	**0.014**	**0.015**	**0.011**	**0.017**	**0.010**	**0.018**	**0.018**	**0.017**	**0.018**	**0.019**	**0.019**
Mercury, Total (mg/L)	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	-	-	< 0.00020
Molybdenum, Total (mg/L)	**0.13**	**0.14**	**0.14**	**0.13**	**0.13**	**0.13**	**0.14**	**0.13**	**0.14**	**0.12**	**0.11**	**0.11**
Selenium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Thallium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Radium-226 & 228 Combined (pCi/L)	0.641 ± 1.06 (2.07)	0.794 ± 0.879 (1.48)	1.12 ± 0.911 (1.79)	**1.45 ± 0.852 (1.29)**	0.561 ± 0.800 (1.59)	0.449 ± 0.764 (1.55)	1.10 ± 0.864 (1.50)	1.15 ± 0.920 (1.54)	0.0414 ± 0.563 (0.967)	0.291 ± 0.430 (0.710)	**2.56 +/- 1.14 (1.18)**	0.935 ± 0.760 (1.27)

Notes and Abbreviations:

Bold value: *Detection above laboratory reporting limit or minimum detectable concentration (MDC)* **.**
Radiological results are presented as activity plus or minus uncertainty with MDC.
Data presented in this table were verified against the laboratory reports.
µS/cm = micro Siemens per centimeter
Deg C = degrees Celsius
ft btoc = feet below top of casing
mg/L = milligrams per liter
M = Missing Data
N/A = Not Applicable
NTU = Nephelometric Turbidity Unit
pCi/L = picoCuries per liter
su = standard unit
TDS = total dissolved solids
TOC = top of casing

TABLE 1-1
SUMMARY OF ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Location Group	Downgradient															
Location	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38	MW-38
Measure Point (TOC)	832.63	832.63	832.63	832.63	832.63	832.63	832.63	832.63	832.63	832.63	832.63	832.63	832.63	832.63	832.63	832.63
Sample Name	MW-38-030718	DUP-03	MW-38-050918	DUP-050918	MW-38-070218	MW-38-081418	DUP-081418	MW-38-100318	MW-38-111918	MW-38-011119	DUP-011119	MW-38-031919	MW-38-120619	MW-38-031020	MW-38-091520	MW-38-120120
Sample Date	03/07/2018	03/07/2018	05/09/2018	05/09/2018	07/02/2018	08/14/2018	08/14/2018	10/03/2018	11/19/2018	01/11/2019	01/11/2019	03/19/2019	12/06/2019	03/10/2020	9/15/2020	12/1/2020
Depth to Water (ft btoc)	16.11	-	15.98	-	16.43	16.84	-	16.69	14.56	14.14	-	14.29	14.06	14.75	16.53	16.61
Temperature, Field (Deg C)	14.0	-	16.84	-	17.88	17.49	-	18.50	14.38	13.56	-	13.70	14.49	10.59	20.54	15.68
Conductivity (µS/cm)	2824	-	3080	-	2790	2770	-	2830	2830	2800	-	2940	2834	2476	2700	2990
Turbidity (NTU)	2.14	-	0.46	-	1.36	1.41	-	0.39	1.08	0.72	-	0.85	0.96	0.44	0.0	0.0
Antimony, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Arsenic, Total (mg/L)	**0.015**	**0.015**	**0.014**	**0.013**	**0.013**	**0.013**	**0.014**	**0.014**	**0.014**	**0.014**	**0.014**	**0.015**	**0.015**	**0.015**	**0.029**	**0.019**
Barium, Total (mg/L)	**0.038**	**0.038**	**0.037**	**0.032**	**0.034**	**0.034**	**0.032**	**0.032**	**0.032**	**0.032**	**0.034**	**0.031**	**0.031**	**0.033**	**0.040**	**0.036**
Beryllium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Cadmium, Total (mg/L)	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	-	-	< 0.00050
Chromium, Total (mg/L)	< 0.0050	< 0.0050	< 0.0050	< 0.00050	< 0.00050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	-	-	< 0.0050
Cobalt, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	**0.0011**	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Fluoride (mg/L)	**5.0**	**5.1**	**5.0**	**3.5**	**5.1**	**5.5**	**5.5**	**5.3**	**4.8**	**4.7**	**5.0**	**4.7**	**5.0**	**4.9**	**2.8**	**4.6**
Lead, Total (mg/L)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	-	-	< 0.010
Lithium, Total (mg/L)	**0.079**	**0.078**	**0.083**	**0.048**	**0.077**	**0.072**	**0.075**	**0.076**	**0.071**	**0.076**	**0.076**	**0.076**	**0.075**	**0.074**	**0.071**	**0.084**
Mercury, Total (mg/L)	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	-	-	< 0.00020
Molybdenum, Total (mg/L)	**0.10**	**0.099**	**0.093**	**0.10**	**0.099**	**0.087**	**0.089**	**0.089**	**0.087**	**0.088**	**0.087**	**0.094**	**0.092**	**0.082**	**0.074**	**0.081**
Selenium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0050	< 0.0010	-	-	< 0.0010
Thallium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Radium-226 & 228 Combined (pCi/L)	1.56 ± 1.04 (1.69)	1.11 ± 0.983 (1.81)	0.862 ± 0.701 (1.22)	0.680 ± 0.720 (1.35)	1.88 ± 1.15 (1.98)	0.377 ± 0.751 (1.47)	0.976 ± 0.829 (1.41)	0.136 ± 0.671 (1.62)	0.951 ± 0.798 (1.30)	0.862 ± 0.805 (1.41)	1.16 ± 0.846 (1.35)	**1.78 ± 0.961 (1.45)**	**1.84 ± 0.756 (1.08)**	0.245 ± 0.440 (0.721)	0.656 +/- 0.534 (0.865)	**1.40 ± 0.686 (0.985)**

Notes and Abbreviations:

Bold value: *Detection above laboratory reporting limit or minimum detectable concentration (MDC)* **.**
Radiological results are presented as activity plus or minus uncertainty with MDC.
Data presented in this table were verified against the laboratory reports.
µS/cm = micro Siemens per centimeter
Deg C = degrees Celsius
ft btoc = feet below top of casing
mg/L = milligrams per liter
M = Missing Data
N/A = Not Applicable
NTU = Nephelometric Turbidity Unit
pCi/L = picoCuries per liter
su = standard unit
TDS = total dissolved solids
TOC = top of casing

HALEY ALDRICH

TABLE 1-1
SUMMARY OF ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Location Group	Downgradient															
Location	MW-39	MW-39	MW-39	MW-39	MW-39	MW-39	MW-39	MW-39	MW-39	MW-39	MW-39	MW-39	MW-39	MW-39 (RESAMPLE)	MW-39	MW-39
Measure Point (TOC)	830.62	830.62	830.62	830.62	830.62	830.62	830.62	830.62	830.62	830.62	830.62	830.62	830.62	830.62	830.62	830.62
Sample Name	MW-39-030818	MW-39-050918	MW-39-070218	MW-39-081418	MW-39-100318	MW-39-111918	MW-39-011119	MW-39-031919	MW-39-120619	DUP-120619	MW-39-031120	DUP-031120	MW-39-091520	MW-39-101920	MW-39-120120	DUP-AP-120120
Sample Date	3/8/2018	05/09/2018	07/02/2018	08/14/2018	10/03/2018	11/19/2018	01/11/2019	03/19/2019	12/06/2019	12/06/2019	03/11/2020	03/11/2020	9/15/2020	10/19/2020	12/1/2020	12/1/2020
Depth to Water (ft btoc)	15.60	14.97	15.40	15.69	15.41	12.74	12.21	12.65	12.10	-	13.38	-	15.50	15.65	15.38	-
Temperature, Field (Deg C)	12.22	18.41	18.88	18.82	19.04	15.46	14.01	15.09	14.83	-	10.34	-	19.10	15.05	12.93	-
Conductivity (µS/cm)	3640	4030	3850	3880	4030	4010	3820	4155	3009	-	3217	-	3920	3980	4180	-
Turbidity (NTU)	0.44	0.27	0.03	0.02	0.15	0.54	0.28	0.53	0.92	-	0.61	-	0.0	0.0	22.2	-
Antimony, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	-	-	< 0.0010	< 0.0010
Arsenic, Total (mg/L)	**0.012**	**0.013**	**0.013**	**0.013**	**0.013**	**0.014**	**0.010**	**0.011**	**0.014**	**0.014**	**0.011**	**0.011**	**0.011**	-	**0.013**	**0.014**
Barium, Total (mg/L)	**0.031**	**0.033**	**0.032**	**0.032**	**0.033**	**0.032**	**0.030**	**0.030**	**0.030**	**0.031**	**0.033**	**0.033**	**0.034**	-	**0.034**	**0.034**
Beryllium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	-	-	< 0.0010	< 0.0010
Cadmium, Total (mg/L)	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	-	-	-	-	< 0.00050	< 0.00050
Chromium, Total (mg/L)	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.00050	< 0.0050	< 0.0050	-	-	-	-	< 0.0050	< 0.0050
Cobalt, Total (mg/L)	< 0.0010	**0.0011**	**0.0014**	**0.0016**	**0.0014**	< 0.0010	**0.0013**	**0.0012**	< 0.0010	< 0.0010	-	-	-	-	**0.0011**	**0.0011**
Fluoride (mg/L)	**2.7**	**2.9**	**3.3**	**3.0**	**3.2**	**3.5**	**2.9**	**1.9**	**2.9**	**2.9**	**2.2**	**2.2**	**1.8**	-	**1.8**	**1.8**
Lead, Total (mg/L)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	-	-	-	-	< 0.010	< 0.010
Lithium, Total (mg/L)	**0.038**	**0.050**	**0.049**	**0.047**	**0.049**	**0.062**	**0.043**	**0.045**	**0.045**	**0.042**	**0.037**	**0.037**	**0.037**	-	**0.039**	**0.043**
Mercury, Total (mg/L)	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	-	-	-	-	< 0.00020	< 0.00020
Molybdenum, Total (mg/L)	**0.11**	**0.11**	**0.11**	**0.093**	**0.089**	**0.14**	**0.11**	**0.15**	**0.19**	**0.19**	**0.18**	**0.18**	**0.23**	**0.23**	**0.20**	**0.20**
Selenium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0050	< 0.0010	< 0.0010	-	-	-	-	< 0.0010	< 0.0010
Thallium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	-	-	< 0.0010	< 0.0010
Radium-226 & 228 Combined (pCi/L)	0.966 ± 0.938 (1.67)	0.795 ± 0.6589 (1.14)	1.47 ± 1.04 (1.81)	1.05 ± 0.884 (1.47)	0.582 ± 0.806 (1.50)	1.23 ± 0.975 (1.76)	0.782 ± 1.01 (1.88)	1.62 ±1.31 (2.31)	0.760 ± 0.619 (1.01)	0.000 ± 0.461 (0.943)	0.484 ± 0.547 (0.860)	0.116 ± 0.444 (0.706)	0.923 +/- 0.562 (0.971)	-	**1.31 ± 0.702 (1.03)**	0.890 ± 0.715 (1.15)

Notes and Abbreviations:

Bold value: *Detection above laboratory reporting limit or minimum detectable concentration (MDC)* **.**
Radiological results are presented as activity plus or minus uncertainty with MDC.
Data presented in this table were verified against the laboratory reports.
µS/cm = micro Siemens per centimeter
Deg C = degrees Celsius
ft btoc = feet below top of casing
mg/L = milligrams per liter
M = Missing Data
N/A = Not Applicable
NTU = Nephelometric Turbidity Unit
pCi/L = picoCuries per liter
su = standard unit
TDS = total dissolved solids
TOC = top of casing

HALEY ALDRICH

TABLE 1-1
SUMMARY OF ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Location Group	**Downgradient**												
Location	MW-40	MW-40	MW-40	MW-40	MW-40	MW-40	MW-40	MW-40	MW-40	MW-40	MW-40	MW-40	MW-40
Measure Point (TOC)	831.358	831.358	831.358	831.358	831.358	831.358	831.358	831.358	831.358	831.358	831.358	831.358	831.358
Sample Name	MW-40-030818	MW-40-050918	MW-40-070218	MW-40-081418	MW-40-100318	MW-40-111918	DUP-111918	MW-40-011119	MW-40-031919	MW-40-120619	MW-40-031120	MW-40-091520	MW-40-120120
Sample Date	03/08/2018	05/09/2018	07/02/2018	08/14/2018	10/03/2018	11/19/2018	11/19/2018	01/11/2019	03/19/2019	12/06/2019	03/11/2020	9/15/2020	12/1/2020
Depth to Water (ft btoc)	16.17	15.60	16.01	16.25	16.01	13.43	-	12.72	13.25	12.69	14.03	15.96	15.95
Temperature, Field (Deg C)	13.17	18.47	20.00	20.03	20.63	15.34	-	13.79	16.01	14.92	11.79	21.15	14.58
Conductivity (µS/cm)	3767	3980	3600	3550	3610	3580	-	3440	3678	2686	2693	3130	3140
Turbidity (NTU)	0.79	0.21	0.39	0.10	1.22	0.82	-	0.75	0.68	2.68	0.32	0.0	5.0
Antimony, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Arsenic, Total (mg/L)	**0.013**	**0.014**	**0.014**	**0.014**	**0.014**	**0.027**	**0.027**	**0.014**	**0.015**	**0.015**	**0.014**	**0.014**	**0.014**
Barium, Total (mg/L)	**0.037**	**0.039**	**0.036**	**0.035**	**0.036**	**0.035**	**0.032**	**0.034**	**0.033**	**0.031**	**0.032**	**0.034**	**0.034**
Beryllium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Cadmium, Total (mg/L)	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	-	-	< 0.00050
Chromium, Total (mg/L)	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	-	-	< 0.0050
Cobalt, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Fluoride (mg/L)	**1.6**	**1.9**	**2.1**	**1.9**	**2.0**	**1.7**	**3.6**	**1.5**	**1.2**	**1.6**	**1.6**	< 0.20	**1.3**
Lead, Total (mg/L)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	-	-	< 0.010
Lithium, Total (mg/L)	**0.046**	**0.056**	**0.052**	**0.048**	**0.053**	**0.047**	**0.059**	**0.045**	**0.049**	**0.045**	**0.041**	**0.038**	**0.044**
Mercury, Total (mg/L)	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	-	-	< 0.00020
Molybdenum, Total (mg/L)	**0.14**	**0.15**	**0.19**	**0.16**	**0.16**	**0.062**	**0.062**	**0.15**	**0.15**	**0.11**	**0.096**	**0.079**	**0.076**
Selenium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0050	< 0.0010	-	-	< 0.0010
Thallium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Radium-226 & 228 Combined (pCi/L)	1.00 ± 0.876 (1.60)	0.277 ± 0.632 (1.22)	0.633 ± 0.818 (1.69)	0.900 ± 0.806 (1.43)	0.184 ± 0.775 (1.65)	0.810 ± 0.790 (1.40)	**1.82 ± 1.01 (1.50)**	0.481 ± 0.717 (1.39)	1.26 ± 0.956 (1.63)	0.912 ± 0.613 (0.929)	0.553 ± 0.488 (0.651)	**1.26 +/- 0.629 (0.970)**	**1.61 ± 0.716 (0.853)**

Notes and Abbreviations:

Bold value: *Detection above laboratory reporting limit or minimum detectable concentration (MDC)* **.**
Radiological results are presented as activity plus or minus uncertainty with MDC.
Data presented in this table were verified against the laboratory reports.
µS/cm = micro Siemens per centimeter
Deg C = degrees Celsius
ft btoc = feet below top of casing
mg/L = milligrams per liter
M = Missing Data
N/A = Not Applicable
NTU = Nephelometric Turbidity Unit
pCi/L = picoCuries per liter
su = standard unit
TDS = total dissolved solids
TOC = top of casing

HALEY ALDRICH

TABLE 1-1
SUMMARY OF ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Location Group	**Downgradient**															
Location	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K	MW-K
Measure Point (TOC)	842.6	842.6	842.6	842.6	842.6	842.6	842.6	842.6	842.6	842.6	842.6	842.6	842.6	842.6	842.6	842.6
Sample Name	MW-K-051018	MW-K-070218	DUP-070218	MW-K-081418	MW-K-100318	MW-K-111918	MW-K-121218	DUP-121218	MW-K-011119	MW-K-031919	DUP-031919	MW-K-120619	MW-K-031120	MW-K-091520	DUP-AP-091520	MW-K-120120
Sample Date	05/10/2018	07/02/2018	07/02/2018	08/14/2018	10/03/2018	11/19/2018	12/12/2018	12/12/2018	01/11/2019	03/19/2019	03/19/2019	12/06/2019	03/11/2020	9/15/2020	9/15/2020	12/1/2020
Depth to Water (ft btoc)	26.35	26.77	-	27.18	27.0	24.68	23.21	-	24.32	24.55	-	24.24	25.12	27.11	-	27.05
Temperature, Field (Deg C)	17.43	19.05	-	18.69	19.12	14.96	14.80	-	13.77	14.63	-	14.72	10.17	18.70	-	15.86
Conductivity (µS/cm)	4230	4100	-	4070	4370	4570	4340	-	4640	5359	-	4793	4708	5030	-	5010
Turbidity (NTU)	5.74	2.58	-	5.43	1.68	1.64	1.19	-	1.55	0.85	-	1.06	0.66	0.8	-	0.0
Antimony, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	-	< 0.0010
Arsenic, Total (mg/L)	**0.075**	**0.070**	**0.070**	**0.073**	**0.072**	**0.069**	**0.069**	**0.070**	**0.070**	**0.075**	**0.079**	**0.076**	**0.067**	**0.076**	**0.077**	**0.067**
Barium, Total (mg/L)	**0.052**	**0.042**	**0.043**	**0.041**	**0.045**	**0.044**	**0.042**	**0.041**	**0.041**	**0.043**	**0.043**	**0.040**	**0.043**	**0.038**	**0.037**	**0.038**
Beryllium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	-	< 0.0010
Cadmium, Total (mg/L)	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	-	-	-	< 0.00050
Chromium, Total (mg/L)	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	-	-	-	< 0.0050
Cobalt, Total (mg/L)	**0.0028**	**0.0015**	**0.0011**	**0.0016**	**0.0014**	**0.0011**	**0.0015**	**0.0014**	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	-	< 0.0010
Fluoride (mg/L)	**3.4**	**3.5**	**3.8**	**0.76**	**3.5**	**3.2**	**3.1**	**3.1**	**3.0**	**2.2**	**2.0**	**2.9**	**2.7**	**3.4**	**3.4**	**3.0**
Lead, Total (mg/L)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	-	-	-	< 0.010
Lithium, Total (mg/L)	**0.051**	**0.067**	**0.069**	**0.063**	**0.070**	**0.066**	**0.076**	**0.077**	**0.076**	**0.084**	**0.084**	**0.089**	**0.077**	**0.077**	**0.076**	**0.082**
Mercury, Total (mg/L)	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	-	-	-	< 0.00020
Molybdenum, Total (mg/L)	**0.040**	**0.032**	**0.030**	**0.027**	**0.027**	**0.018**	**0.022**	**0.022**	**0.014**	**0.014**	**0.015**	**0.0096**	**0.016**	**0.021**	**0.022**	**0.023**
Selenium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	-	< 0.0010
Thallium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0050	< 0.0050	-	-	-	< 0.0010
Radium-226 & 228 Combined (pCi/L)	0.866 ± 0.798 (1.36)	1.60 ± 0.898 (1.61)	1.07 ± 0.955 (1.74)	**2.73 ± 1.06 (1.36)**	0.253 ± 0.835 (1.84)	0.864 ± 0.764 (0.991)	1.16 ± 0.761 (1.18)	**1.66 ± 1.02 (1.55)**	0.800 ± 0.848 (1.60)	0.951 ± 0.839 (1.60)	**1.93 ± 1.03 (1.53)**	0.547 ± 0.663 (1.12)	**1.21 ± 0.534 (0.642)**	**2.05 +/- 0.755 (1.12)**	0.901 +/- 0.722 (1.35)	**1.28 ± 0.727 (0.975)**

Notes and Abbreviations:

Bold value: *Detection above laboratory reporting limit or minimum detectable concentration (MDC)* **.**
Radiological results are presented as activity plus or minus uncertainty with MDC.
Data presented in this table were verified against the laboratory reports.
µS/cm = micro Siemens per centimeter
Deg C = degrees Celsius
ft btoc = feet below top of casing
mg/L = milligrams per liter
M = Missing Data
N/A = Not Applicable
NTU = Nephelometric Turbidity Unit
pCi/L = picoCuries per liter
su = standard unit
TDS = total dissolved solids
TOC = top of casing

TABLE 1-1
SUMMARY OF ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Location Group	Downgradient												
Location	MW-L	MW-L	MW-L	MW-L	MW-L	MW-L	MW-L	MW-L	MW-L	MW-L	MW-L	MW-L	MW-L
Measure Point (TOC)	843.05	843.05	843.05	843.05	843.05	843.05	843.05	843.05	843.05	843.05	843.05	843.05	843.05
Sample Name	MW-L-051018	MW-L-070218	MW-L-081418	MW-L-100318	DUP-100318	MW-L-111918	MW-L-121218	MW-L-011119	MW-L-031919	MW-L-120619	MW-L-031120	MW-L-091520	MW-L-120120
Sample Date	05/10/2018	07/02/2018	08/14/2018	10/03/2018	10/03/2018	11/19/2018	12/12/2018	01/11/2019	03/19/2019	12/06/2019	03/11/2020	9/15/2020	12/1/2020
Depth to Water (ft btoc)	27.24	27.63	27.96	27.73	-	25.17	23.64	24.68	25.08	24.24	25.81	27.93	27.79
Temperature, Field (Deg C)	17.48	19.31	19.61	20.19	-	16.06	15.46	13.50	14.78	14.76	10.38	20.02	15.65
Conductivity (µS/cm)	4330	4250	4530	4910	-	5320	5270	5430	5589	3800	3790	4590	4570
Turbidity (NTU)	10.43	4.86	1.13	1.04	-	3.34	1.24	1.22	1.03	0.71	0.51	0.0	0.0
Antimony, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Arsenic, Total (mg/L)	**0.021**	**0.022**	**0.020**	**0.021**	**0.021**	**0.024**	**0.025**	**0.025**	**0.026**	**0.029**	**0.024**	**0.026**	**0.024**
Barium, Total (mg/L)	**0.094**	**0.055**	**0.047**	**0.059**	**0.060**	**0.050**	**0.042**	**0.043**	**0.039**	**0.037**	**0.035**	**0.035**	**0.035**
Beryllium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Cadmium, Total (mg/L)	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	< 0.00050	-	-	< 0.00050
Chromium, Total (mg/L)	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.0050	< 0.00050	< 0.0050	-	-	< 0.0050
Cobalt, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	-	-	< 0.0010
Fluoride (mg/L)	**2.2**	**2.0**	**1.9**	**2.1**	**2.1**	**1.8**	**2.1**	**2.0**	**1.0**	**2.0**	**2.4**	**2.2**	**1.9**
Lead, Total (mg/L)	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	-	-	< 0.010
Lithium, Total (mg/L)	**0.044**	**0.038**	**0.045**	**0.050**	**0.046**	**0.051**	**0.049**	**0.046**	**0.053**	**0.057**	**0.057**	**0.055**	**0.065**
Mercury, Total (mg/L)	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	< 0.00020	-	-	< 0.00020
Molybdenum, Total (mg/L)	**0.038**	**0.043**	**0.039**	**0.038**	**0.038**	**0.041**	**0.047**	**0.047**	**0.051**	**0.055**	**0.049**	**0.054**	**0.048**
Selenium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0050	< 0.0010	-	-	< 0.0010
Thallium, Total (mg/L)	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0050	-	-	< 0.0010
Radium-226 & 228 Combined (pCi/L)	1.01 ± 0.678 (1.21)	1.23 ± 0.917 (1.72)	1.01 ± 0.806 (1.36)	0.597 ± 0.927 (1.84)	0.617 ± 0.886 (1.72)	**2.08 ± 1.23 (1.91)**	1.16 ± 0.880 (1.57)	1.26 ± 0.847 (1.40)	0.483 ± 0.746 (1.50)	0.482 ± 0.632 (0.980)	**0.939 ± 0.500 (0.679)**	**1.23 +/- 0.623 (0.962)**	1.01 ± 0.647 (1.02)

Notes and Abbreviations:

Bold value: *Detection above laboratory reporting limit or minimum detectable concentration (MDC)* **.**
Radiological results are presented as activity plus or minus uncertainty with MDC.
Data presented in this table were verified against the laboratory reports.
µS/cm = micro Siemens per centimeter
Deg C = degrees Celsius
ft btoc = feet below top of casing
mg/L = milligrams per liter
M = Missing Data
N/A = Not Applicable
NTU = Nephelometric Turbidity Unit
pCi/L = picoCuries per liter
su = standard unit
TDS = total dissolved solids
TOC = top of casing

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TABLE 2-1
HYDROGEOLOGIC CHARACTERIZATION DATA FOR THE ASH PONDS CCR MANAGEMENT UNIT
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Unsaturated Material Overlaying Uppermost Aquifer Characteristics	
Lithology (Terrace Deposits)	clay, sand, and gravel
Unsaturated Thickness (Terrace Deposits)	Up to 28 feet
Hydraulic Conductivity (Terrace Deposits)	2.00×10^{-3} to 4.99×10^{-2} cm/sec[a]
Uppermost Aquifer Characteristics	
Lithology (Terrace Deposits)	clay, sand, and gravel
Aquifer Thickness (Terrace Deposits)	21 to 38 feet
Groundwater Gradient (Terrace Deposits)	0.00091 to 0.0034 feet/foot[b]
Hydraulic Conductivity (Terrace Deposits)	2.00×10^{-3} to 4.99×10^{-2} cm/sec[a]
Groundwater Flow Rate (Terrace Deposits)	9 to 205 feet/year
Groundwater Flow Direction (Terrace Deposits)	North
Effective Porosity (Terrace Deposits)	0.2
Confining Unit Below the Uppermost Aquifer Characteristics	
Lithology (shale unit of Tonganoxie sandstone member)	shale
Unit Thickness (shale unit of Tonganoxie sandstone member)	>5 feet
Hydraulic Conductivity (shale unit of Tonganoxie sandstone member)	1×10^{-6} cm/sec[c]
Effective Porosity (shale unit of Tonganoxie sandstone member)	1

Notes:
[a] = Hydraulic conductivity value from slug tests completed in November 2020.
[b] = Data based on December 2020 groundwater potentiometric surface contour data.
[c] = Hydraulic conductivity value from Black & Veatch, 2005.
cm/sec = centimeters per second

TABLE 2-2
STATISTICALLY SIGNIFICANT LEVELS OF APPENDIX IV CONSTITUENTS
MARCH 2020 SAMPLING EVENT
LAWRENCE ENERGY CENTER
INACTIVE ASH PONDS

Constituent	Well ID	Groundwater Protection Standard[1] (GWPS) (mg/L)
Arsenic	MW-38	0.010
	MW-39	
	MW-40	
	MW-K	
	MW-L	
Fluoride[2]	MW-38	4.0
Lithium	MW-38	0.040
	MW-40	
	MW-K	
	MW-L	
Molybdenum[3]	MW-39	0.149

Notes:

mg/L = milligrams per liter

[1] = Pursuant to §257.95(h), GWPS for each of the Appendix IV constituents have been set equal to the highest value of the maximum contaminant level (established under §§141.62 and 141.66), levels provided in 40 CFR §257.95(h)(2) (from regional screening levels), or background concentrations.

[2] = An alternate source demonstration (ASD) was completed for the statistically significantly level reported at MW-38.

[3] = Since the GWPS for molybdenum at the Ash Ponds is determined based on the background concentration, the GWPS provided in this CMA report has been updated since the initial statistically significant limit was observed on the March 2020 semi-annual assessment monitoring data.

TABLE 5-1
SUMMARY OF CORRECTIVE MEASURES
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Alternative Number	Remedial Alternative Description	THRESHOLD CRITERIA: Be protective of human health and the environment	THRESHOLD CRITERIA: Attain the groundwater protective standard	THRESHOLD CRITERIA: Control the source of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents into the environment	THRESHOLD CRITERIA: Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems	THRESHOLD CRITERIA: Management of waste to comply with all applicable RCRA requirements	BALANCING CRITERIA: CATEGORY 1 Long- and Short-Term Effectiveness, Protectiveness, and Certainty of Success that the remedy will prove successful	Sub-Category 1: 1 *Magnitude of reduction of existing risks*	Sub-Category 1: 2 *Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy*	Sub-Category 1: 3 *Type and degree of long-term management required including monitoring, operation and maintenance*	Sub-Category 1: 4 *Short-term risk to community or environment during implementation of remedy*	Sub-Category 1: 5 *Time until full protection is achieved*	Sub-Category 1: 6 *Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment*	Sub-Category 1: 7 *Long-term reliability of engineering and institutional controls*	Sub-Category 1: 8 *Potential need for replacement of the remedy*	CATEGORY 2 Effectiveness in controlling the source to reduce further releases	Sub-Cat. 2: 1 *Extent to which containment practices will reduce further releases*	Sub-Cat. 2: 2 *Extent to which treatment technologies may be used*	CATEGORY 3 The ease or difficulty of implementation	Sub-Category 3: 1 *Degree of difficulty associated with constructing the technology*	Sub-Category 3: 2 *Expected operational reliability of the technologies*	Sub-Category 3: 3 *Need to coordinate with and obtain necessary approvals and permits from other agencies*	Sub-Category 3: 4 *Availability of necessary equipment and specialists*	Sub-Category 3: 5 *Available capacity and location of needed treatment, storage, and disposal services*
1	Closure by Removal (CBR) with Monitored Natural Attenuation (MNA) and Remediation Performance Monitoring	✓	✓	✓	✓	✓	Green	Green	Green	Green	Green	Red	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
2	CBR with Groundwater Pumping and Ex-Situ Treatment	✓	✓	✓	✓	✓	Yellow	Green	Green	Red	Green	Green	Yellow	Yellow	Yellow	Yellow	Green	Yellow	Yellow	Yellow	Red	Yellow	Yellow	Yellow
3	CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall	✓	✓	✓	✓	✓	Yellow	Green	Green	Red	Yellow	Green	Yellow	Yellow	Yellow	Red	Green	Red	Red	Red	Yellow	Red	Red	Yellow
4	CBR with In-Situ Groundwater Treatment	✓	✓	✓	✓	✓	Red	Green	Green	Yellow	Yellow	Yellow	Green	Red	Red	Yellow	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Red	Green

COLOR LEGEND
- Green: Most favorable when compared to other alternatives
- Yellow: Less favorable when compared to other alternatives
- Red: Least favorable when compared to other alternatives

Note: Removal of LEC Ash Ponds completed in 2018. Removal of Ash Pond berms to be completed in 2021

This Summary of Corrective Measures and associated CMA Report Section 5 text also satisfies the requirements of 257.96(c).

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FIGURES

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. IMAGERY SOURCE: ESRI

0 2,000 4,000
SCALE IN FEET

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EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

SITE LOCATION MAP

evergy

MARCH 2021

FIGURE 1-1

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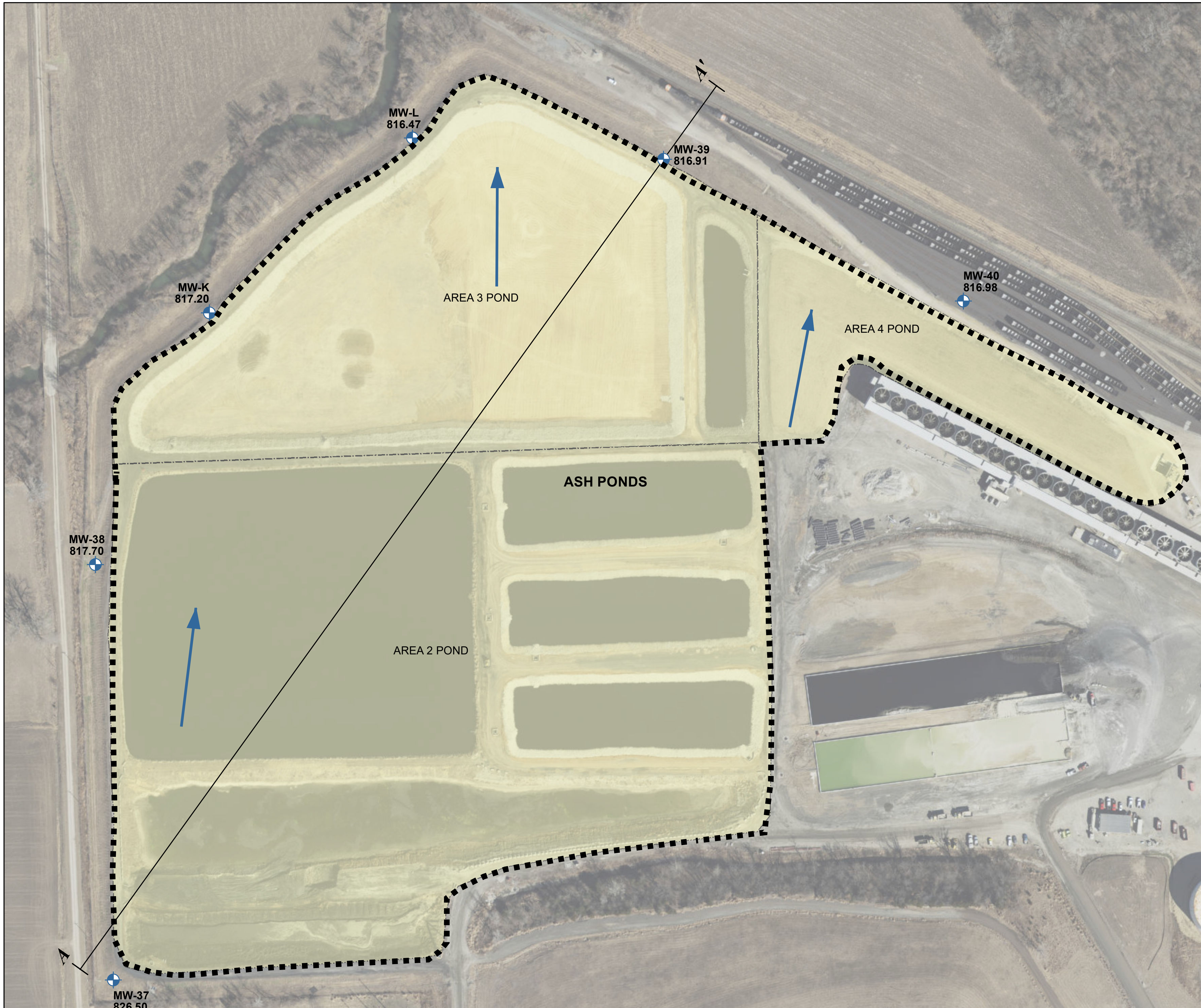

LEGEND

MONITORING WELL

MW-K
317.20 WELL ID AND GROUNDWATER ELEVATION (MARCH 2020)

CROSS SECTION LINE

GENERAL SITE GROUNDWATER FLOW DIRECTION

LIMITS OF FORMER ASH PONDS

NOTE: ASH POND REMOVAL COMPLETED IN 2018. REMOVAL OF REMAINING ASH POND BERMS TO BE COMPLETED IN 2021

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, APRIL 17, 2018

N

0 200 400
SCALE IN FEET

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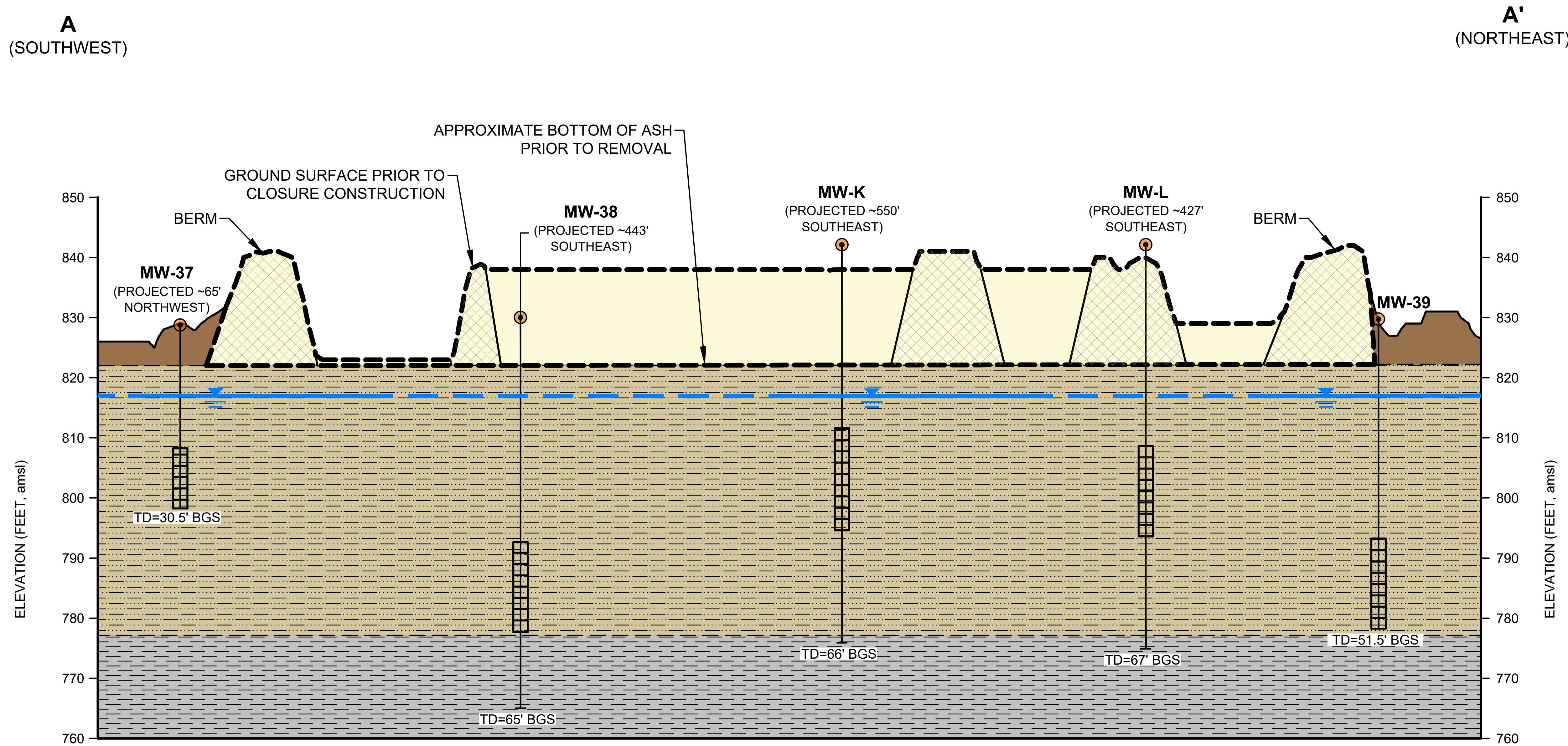
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

MONITORING WELL LOCATION MAP AND GENERAL GROUNDWATER FLOW DIRECTION

evergy

MARCH 2021

FIGURE 1-2



LEGEND

- LIMITS OF FORMER ASH PONDS. ASH POND REMOVAL COMPLETED IN 2018. REMOVAL OF REMAINING ASH POND BERMS TO BE COMPLETED IN 2021
- BERM
- OVERBURDEN
- TERRACE DEPOSITS
- SHALE
- INFERRED GEOLOGIC CONTACT
- INFERRED WATER TABLE
- APPROXIMATE WATER LEVEL
- MW-X WELL IDENTIFICATION
- GROUND SURFACE
- ACTUAL GROUND SURFACE ELEVATION
- WATER LEVEL
- WELL SCREEN
- TD=4X' BGS TOTAL DEPTH OF BOREHOLE

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. VERTICAL SCALE IS EXAGGERATED 15 TIMES.

HORIZ. 0 200 400
VERT. 0 20 40
SCALE IN FEET

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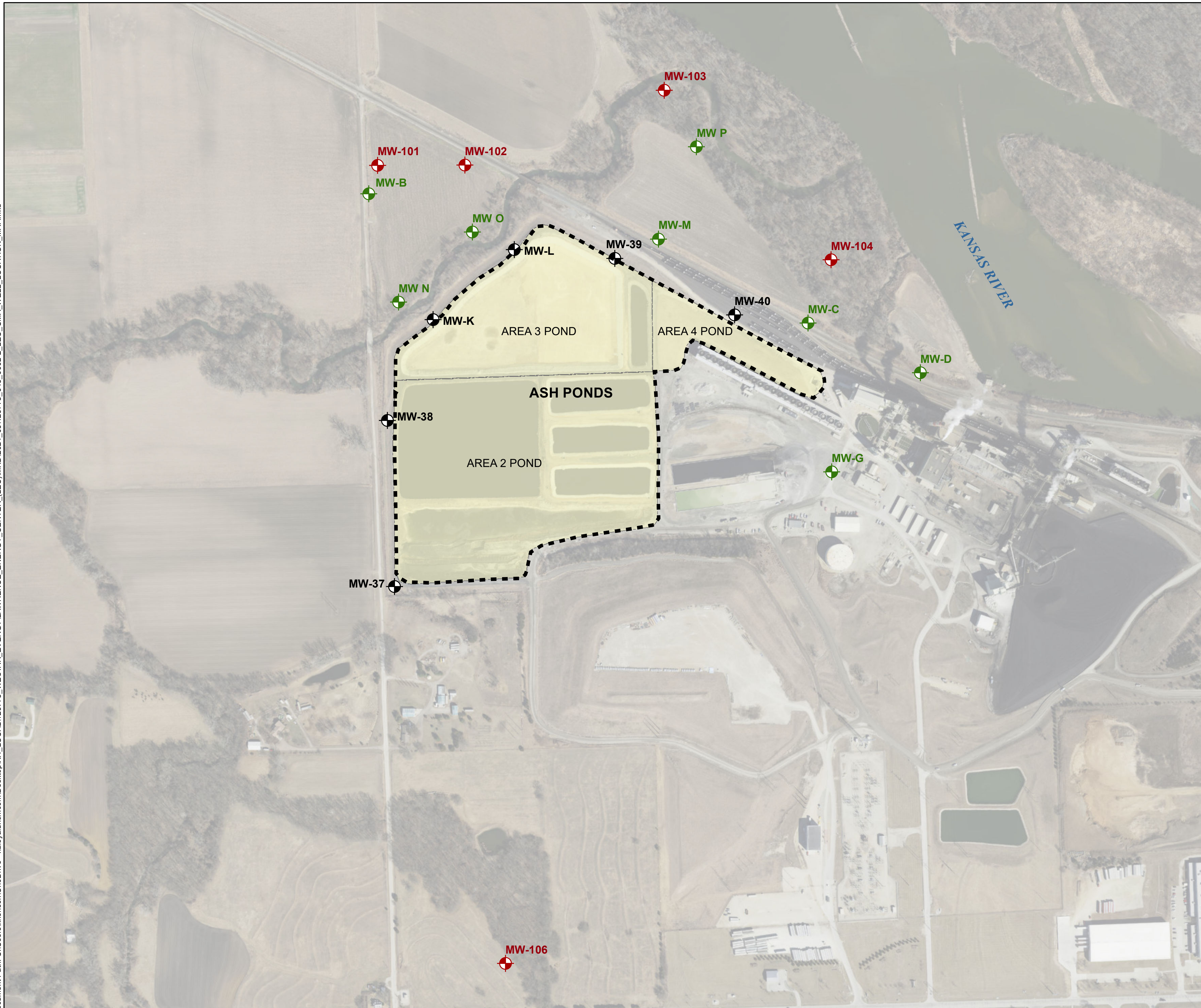
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

GENERALIZED GEOLOGIC CROSS SECTION A-A' (PRE-CLOSURE CONSTRUCTION)

SCALE: AS SHOWN
MARCH 2021

FIGURE 2-1



LEGEND

- ASH PONDS COAL COMBUSTION RESIDUAL (CCR) RULE MONITORING WELL
- NATURE AND EXTENT MONITORING WELL
- HISTORICAL MONITORING WELL
- LIMITS OF FORMER ASH PONDS

NOTE: ASH POND REMOVAL COMPLETED IN 2018. REMOVAL OF REMAINING ASH POND BERMS TO BE COMPLETED IN 2021

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: ESRI, APRIL 17, 2018

0 500 1,000
SCALE IN FEET

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EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

MONITORING WELL LOCATION MAP - AREA 2, 4, AND 4 PONDS (PRE-CLOSURE CONSTRUCTION)

evergy

MARCH 2021

FIGURE 2-2

Document Path: C:\Users\khensen\OneDrive - haleyaldrich.com\Desktop\KH_LOCAL\129778_WESTAR_EVERGY\LAWRENCE_ENERGY_CENTER_(LEC)\MXD\2021_03\129778_043_0002-2_LEC_CMA_WELL_LOCATION_MAP.mxd

FIGURE 4-1
REMEDIAL ALTERNATIVES ROADMAP
EVERGY KANSAS CENTRAL, INC
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

Alternative Number	Remedial Alternative Description	Ash Pond Closure Description	Groundwater Remedy Components		
			A. Groundwater Remedy Approach	**B. Groundwater Treatment Method**	**C. Post-Closure Actions**
1	**Closure by Removal (CBR) with Monitored Natural Attenuation (MNA) and Remediation Performance Monitoring**	**CBR (Planned Completion 2021)**	**Natural Attenuation with Performance Monitoring** Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation following source removal	**No Active Treatment** No active treatment technologies for groundwater to address CCR constituents	**MNA/Performance Monitoring** Long-term groundwater monitoring to confirm reduction of CCR constituents
2	**CBR with Groundwater Pumping and Ex-Situ Treatment**		**Pump & Treat** Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells. Treat using on-site or off-site above ground system	**Ex-Situ Treatment** Treatment system to remove CCR constituents from groundwater and discharge under applicable permits	**Pump & Treat Long-Term** Continue to operate hydraulic containment system to maintain reduction of CCR constituents in groundwater
3	**CBR with Groundwater Pumping and Ex-Situ Treatment and Barrier Wall**		**Barrier Wall with Pump & Treat** Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells and a low permeability barrier wall		
4	**CBR with In-Situ Groundwater Treatment**		**Subsurface Treatment System** Mitigate off-site migration of groundwater with CCR constituents above GWPS using in-situ treatment methods, pilot testing required to demonstrate effectiveness.	**In-Situ Treatment** Subsurface treatment to reduce CCR constituent concentrations in groundwater	**In-Situ Treatment Long-Term** Continue in-situ treatment of groundwater to maintain reduction of CCR constituents in groundwater

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Appendix A

Groundwater Risk Evaluation

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REPORT ON

GROUNDWATER RISK EVALUATION
LAWRENCE ENERGY CENTER
AREA 2 POND, AREA 3 POND, AND AREA 4 POND
LAWRENCE, KANSAS

by
Haley & Aldrich, Inc.
Cleveland, Ohio

for
Evergy Kansas Central, Inc.
Topeka, Kansas

File No. 129778-043
March 2021

Public

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List of Abbreviations

Abbreviation	Definition
ACS	American Cancer Society
ASD	Alternative Source Demonstration
CCR	Coal Combustion Residual
CMA	Corrective Measures Assessment
CSM	Conceptual Site Model
Evergy	Evergy Kansas Central, Inc.
GWPS	Groundwater Protection Standards
Haley & Aldrich	Haley & Aldrich, Inc.
KDHE	Kansas Department of Health & Environment
LEC	Lawrence Energy Center
MCL	Maximum Contaminant Level
mg/L	Milligram per Liter
pCi/L	Pico-Curies per Liter
RBSL	Risk-Based Screening Level
RSL	Regional Screening Level
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
SW-DAF	Surface Water Dilution and Attenuation Factor
ug/L	Microgram per Liter
USEPA	United States Environmental Protection Agency
WWC5	Kansas Water Well Completion Records database

1. Introduction

Haley & Aldrich, Inc. (Haley & Aldrich) was retained by Evergy Kansas Central, Inc. (Evergy; f/k/a/ Westar Energy, Inc.) to prepare this groundwater risk evaluation for the Coal Combustion Residual (CCR) units former Area 2 Pond, Area 3 Pond, and Area 4 Pond (collectively, Ash Ponds), herein referred to as the "Site", located at the Lawrence Energy Center (LEC). It is noted that the LEC Ash Ponds were removed (completed 2020), and removal of the former Ash Pond berms is underway and is scheduled to be completed by the end of Q2 2021.

Evergy owns and operates the LEC, a coal-fired power plant located adjacent to the Kansas River northwest of the City of Lawrence in Douglas County, Kansas. The facility is bounded to the north and west by Baldwin Creek, to the north by the Kansas River, to the south by agricultural, and industrial areas, to the south/southwest by residential areas, and to the east by woods and farmland. The former Ash Ponds are located to the west of the LEC plant site and consist of a series of settling ponds that were historically used to manage CCR material but have been replaced by a concrete tank system. Figure 1 shows the location of the facility, and the location of the Ash Ponds.

The United States Environmental Protection Agency (USEPA) issued a final rule for "Disposal of Coal Combustion Residuals from Electric Utilities" in 2015 (the CCR Rule) (USEPA, 2015). One of the requirements in the CCR Rule is that utilities monitor groundwater at coal ash management facilities, and that the data be reported publicly. Evergy is complying with the CCR Rule and has posted the required information on their publicly available website: https://www.evergy.com/ccr.

This "Groundwater Risk Evaluation" report has been prepared by Haley & Aldrich and is a companion document to the "Corrective Measures Assessment (CMA) for the Lawrence Energy Center – Area 2 Pond, Area 3 Pond, and Area 4 Pond, Lawrence, Kansas" by Haley & Aldrich (2021). The purpose of this risk evaluation report is to provide the information needed to interpret and meaningfully understand the groundwater monitoring data collected and published for the LEC under the CCR Rule.

Beyond the specific monitoring requirements of the CCR Rule, Evergy has also voluntarily taken the additional step to evaluate potential groundwater-to-surface water transport and exposure pathways through the development of risk-based groundwater screening levels that are protective of surface water in the Kansas River and Baldwin Creek. Details about the evaluation are provided in the following section.

2. Approach

The analysis presented in this report was conducted by evaluating the environmental setting of the LEC, including its location and where ash management has occurred at the facility. Information on where groundwater is located at the facility, the rate(s) of groundwater flow, the direction(s) of groundwater flow, and where waterbodies may intercept groundwater flow are reviewed and summarized here.

A conceptual model was developed based on this physical setting information, and the model was used to identify what human populations could contact groundwater and/or surface water in the area of the facility. This information was also used to identify where ecological populations could come into contact with surface water.

Human health risk assessment is a process used to estimate the chance that contact with constituents in the environment may result in harm to people. Generally, there are four components to the process (USEPA, 1989): (1) Hazard Identification/Data Evaluation, (2) Toxicity Assessment, (3) Exposure Assessment, and (4) Risk Characterization.

The USEPA and other regulatory agencies, including the Kansas Department of Health & Environment (KDHE), develop "screening levels" of constituent concentrations in groundwater (and other media) that are considered to be protective of specific human exposures. In developing screening levels, USEPA uses a specific target risk level (component 4) combined with an assumed exposure scenario (component 3) and toxicity information from USEPA (component 2) to derive an estimate of a concentration of a constituent in an environmental medium, for example groundwater, (component 1) that is protective of a person in that exposure scenario (for example, drinking water). Similarly, ecological screening levels for surface water are developed by USEPA and KDHE to be protective of the wide range of potential aquatic ecological resources, or receptors.

Risk-based screening levels are designed to provide a conservative estimate of the concentration to which a receptor (human or ecological) can be exposed without experiencing adverse health effects. Due to the conservative methods used to derive risk-based screening levels, it can be assumed with reasonable certainty that concentrations below screening levels will not result in adverse health effects, and that no further evaluation is necessary. Concentrations above conservative risk-based screening levels do not necessarily indicate that a potential risk exists but indicate that further evaluation may be warranted.

Human health risk-based and ecological risk-based screening levels drawn from USEPA and KDHE sources are used to determine if the concentration levels of constituents in groundwater could pose a risk to human health or the environment that warrants further evaluation.

2.1 CONCEPTUAL SITE MODEL

A conceptual site model (CSM) is used to evaluate the potential for human or ecological exposure to constituents that may have been released to the environment. A human or ecological CSM describes the sources and potential migration pathways through which constituents may have been transported to other environmental media (receiving media), and the human and environmental receptors that may in turn contact the receiving media. The linkage between a receiving medium and potential exposure is called an exposure pathway. For an exposure pathway to be complete, the following conditions must exist (as defined by USEPA (1989)):

1. A source and mechanism of chemical release to the environment;
2. An environmental transport medium (e.g., air, water, soil);
3. A point of potential contact with the receiving medium by a receptor; and
4. A receptor exposure route at the contact point (e.g., inhalation, ingestion, dermal contact).

If any of these four components are not present, the pathway is not complete. The components of the CSM for the LEC are described below and shown on Figure 2.

Some of the questions posed during the CSM evaluation include:

- What is the source? For the evaluation of the ash management operations at LEC, the coal ash stored in the Ash Ponds is the potential source that is reviewed in this risk evaluation; other potential sources at the LEC are not included.
- How can constituents be released from the source? Constituents present in the Ash Ponds can be dissolved into infiltrating water (from precipitation) and those constituents may move through the subsurface into shallow groundwater.
- How and where do constituents travel within a medium? Constituents could move into shallow groundwater. Constituents could move with groundwater as it flows in the downgradient direction. Groundwater flow at the LEC is generally in the northly direction toward Baldwin Creek and the Kansas River.
- What environmental media may be affected by constituent release? Is there a point where a receptor (human or ecological) could contact the constituents in the medium? Receptors could be exposed to constituents in shallow groundwater or in surface water.

Groundwater moves slowly through the rock and soils beneath the ground. Like surface water, it also moves from areas of high elevation to areas of low elevation and can discharge into adjacent surface water bodies. Any potential release of constituents to groundwater from the Ash Ponds will be limited in extent by the general flow of groundwater in the northly direction towards Baldwin Creek and the Kansas River (downgradient) and will not impact surrounding areas to the east, south, and west (upgradient), meaning that groundwater does not flow from the Ash Ponds to the east, south or west. Figure 1 shows the facility location and layout and identifies the adjacent surface water bodies.

CCR-derived constituents present in groundwater may move to adjacent surface water; here, that could be Baldwin Creek and the Kansas River. Thus, the environmental media of interest for this evaluation are:

- Groundwater at the facility;
- Baldwin Creek surface water; and
- Kansas River surface water.

There are no on-site groundwater users at LEC. Water for plant operations is obtained from the Kansas River and potable water is provided by the municipal water utility. The Kansas Geological Survey Kansas Water Well Completion Records database (WWC5) lists nine wells within a one-mile radius of the Ash Ponds boundary (see Figure 3), seven of the wells are located either northeast of the facility on the opposite side of the Kansas River or upgradient (south) of the facility, meaning that groundwater does not flow from the Ash Ponds toward those wells. Two wells (one residential well and one irrigation well) are located just under one mile from the Ash Ponds to the northwest. Because groundwater flows in a northerly direction toward the Kansas River in the area of the Ash Ponds and cannot move beyond the Kansas River, groundwater does not flow from the Ash Ponds towards those wells. Thus, there are no downgradient groundwater users and no complete drinking water exposure pathways to groundwater downgradient of the Ash Ponds.

Depth to groundwater in this area ranges from approximately 8 feet to greater than 20 feet. Thus, because groundwater in some areas is shallow (less than 10 feet deep), construction workers at LEC performing intrusive excavation activities in the future could potentially contact groundwater during a short-term construction/excavation event.

The Kansas River is a supply source for drinking water; the nearest public water supply intake is the City of Lawrence Kaw River Water Treatment Plant located approximately three miles downstream near the City of Lawrence, Kansas. The Kansas River can be used for human recreation – wading, swimming, boating, fishing. The river also serves as habitat for aquatic species – fish, amphibians, etc.

Baldwin Creek can also be used recreationally, though its small size and periodic drying would limit its recreational use mostly to wading. It is assumed that Baldwin Creek's small size and periodic drying would limit its ability to support a consumptive fishery or habitat for aquatic species. The evaluation of Baldwin Creek is discussed further in Section 4.3.

A depiction of the CSM is shown in Figure 2. The potentially complete exposure pathways identified in the figure are those evaluated here:

- Construction Workers (Dermal contact with shallow groundwater during excavation activities);
- Kansas River Recreational User (Recreational use of the Kansas River for swimming, wading, boating, and fishing activities);
- Baldwin Creek Recreational User (Recreational use of Baldwin Creek for wading activities);
- Ecological Receptors (Kansas River); and
- Off-Site Resident (Direct contact with Kansas River surface water used as drinking water).

The potentially complete exposure pathways are evaluated using groundwater analytical data for on-site monitoring wells associated with the Ash Ponds. Figure 1 shows the locations of the groundwater monitoring wells.

Based on this conceptual site model and the facility setting, samples collected from groundwater monitoring wells have been included in the evaluation. The samples have been analyzed for constituents that are commonly associated with CCR, as discussed below. However, it is recognized by the USEPA that all of these constituents can also be naturally occurring and can be found in rocks, soils, water, and sediments; thus, it is necessary to understand what the naturally occurring background levels are for these constituents. The CCR Rule requires sampling and analysis of upgradient and/or background groundwater just for this reason. Background groundwater is measured at locations before groundwater passes beneath the Ash Ponds and is, therefore, unaffected by any potential release of constituents to groundwater from the Ash Ponds. The sampling is detailed in the next section.

Following Section 3, in order to answer the question, “Are the constituent concentrations high enough to potentially exert a toxic effect?” health risk-based screening levels from USEPA and KDHE sources are used for comparison to the data, as described in Sections 4 and 5.

3. Sample Collection and Analysis

3.1 GROUNDWATER SAMPLES

The CCR Rule requires that groundwater monitoring occur at a minimum of one upgradient location and three downgradient locations. For the Ash Ponds evaluation, one upgradient monitoring well was installed southwest of the Ash Ponds to assess background groundwater conditions, and five downgradient groundwater monitoring wells were installed around the west and north perimeter of the Ash Ponds to assess groundwater conditions in the uppermost aquifer at the ash management area. Figure 1 shows the locations of the monitoring wells. Each well is identified by a unique name. MW-38, MW-39, MW-40, MW-K, and MW-L are located downgradient around the perimeter of the Ash Ponds, and MW-37 is the background well that is used to identify upgradient/background conditions in groundwater.

3.2 SAMPLE ANALYSIS

The CCR Rule identifies the constituents that are included for groundwater testing; these are:

Appendix III (Detection Monitoring)	Appendix IV (Assessment Monitoring)	
Boron	Antimony	Lead
Calcium	Arsenic	Lithium
Chloride	Barium	Mercury
pH	Beryllium	Molybdenum
Sulfate	Cadmium	Selenium
TDS	Chromium	Thallium
Fluoride	Cobalt	Radium 226/228
	Fluoride	

The CCR Rule requires eight rounds of groundwater sampling and analysis be conducted for all wells to provide a baseline for current conditions. This was completed with the March 2019 groundwater monitoring event. Under the CCR Rule, further rounds of groundwater sampling analyzing for Appendix III constituents are defined as "Detection" monitoring. Following the March 2019 event, the Ash Ponds prepared for entry into assessment monitoring. One more detection monitoring event was completed in September 2019 before the Ash Ponds entered into assessment monitoring. Assessment Monitoring samples collected in December 2019, March 2020, September 2020, and December 2020 were analyzed for Appendix III and Appendix IV constituents. The "Corrective Measures Assessment (CMA)" report provides more detail on the objectives of the rounds of groundwater sampling. Appendix III and IV analytical results for the baseline and Assessment Monitoring events are summarized in Table 1.

4. Risk-Based Screening Levels

A comprehensive set of risk-based screening levels have been compiled for this evaluation for the four types of potential exposures identified in the CSM discussion above:

- Human health drinking water consumption;
- Construction worker exposure to shallow groundwater during excavation activities;
- Human health recreational use of surface water; and
- Aquatic ecological receptors for surface water.

GWPS used to evaluate potential drinking water exposures for CCR monitoring wells are shown on Table 1. Site-specific risk-based screening levels (RBSLs) for a construction worker are shown on Table 2. Human health and ecological screening levels for surface water used in the evaluation are shown on Tables 3 through 7. Section 5 presents the results of the evaluation.

4.1 GROUNDWATER PROTECTION STANDARDS FOR THE ASH PONDS

It is important to note that the CCR Rule requires that the downgradient monitoring wells be located to represent the quality of groundwater passing the waste boundary of the CCR unit. Moreover, the CCR Rule limits the evaluation of groundwater monitoring data from ash management areas to groundwater protection standards (GWPS), which are protective for use of the groundwater as drinking water, regardless of whether or not that groundwater is used as a source of drinking water.

The GWPS used to evaluate potential drinking water exposure for CCR monitoring wells are defined in the CCR Rule (§257.95 Assessment monitoring program):

> (h) The owner or operator of the CCR unit must establish a groundwater protection standard for each constituent in appendix IV to this part detected in the groundwater. The groundwater protection standard shall be:
>
> > (1) For constituents for which a maximum contaminant level (MCL) has been established under §§141.62 and 141.66 of this title, the MCL for that constituent;
> >
> > (2) For constituents for which an MCL has not been established, the background concentration for the constituent established from wells in accordance with §257.91; or
> >
> > (3) For constituents for which the background level is higher than the MCL identified under paragraph (h)(1) of this section, the background concentration.

Therefore, GWPS were initially the Federal primary drinking water standards, also known as Maximum Contaminant Levels or MCLs (USEPA, 2018a) or background values. USEPA later published Amendments to the National Minimum Criteria Finalized in 2018 (Phase One, Part One) in the Federal Register on July 30, 2018 (USEPA, 2018b). This included revising the GWPS for constituents that do not have an established drinking water standard (or MCL) at §257.95 Assessment monitoring program (h) (2):

Cobalt – 6 ug/L (micrograms per liter)
Lead – 15 ug/L
Lithium – 40 ug/L
Molybdenum – 100 ug/l

In the event the above four constituents occurred at higher levels than the MCL or background levels, these would be the GWPS.

4.2 CALCULATED GROUNDWATER RISK-BASED SCREENING LEVELS – CONSTRUCTION WORKER

Site-specific RBSLs are essentially refined screening levels to account for receptor population characteristics and exposure pathways. As such, the site-specific RBSLs are more realistic than published screening levels and, therefore, are useful for evaluating whether constituents may have the potential to pose health risks above risk thresholds. For example, whereas groundwater that could potentially be encountered by a construction worker during excavation activities could be evaluated using drinking water standards which assume that people are drinking and bathing in the water daily, site-specific RBSLs for construction worker exposure to groundwater reflect the incidental nature of this contact with groundwater (e.g., getting groundwater on the skin and not drinking it). Specifically, the construction worker RBSLs were calculated assuming that dermal contact with groundwater could occur during excavation activities, and that since excavation work is not associated with intense exposures to water (such as is the case of drinking water), incidental ingestion of groundwater would be insignificant. This level of potential exposure is more realistic for a construction worker scenario, therefore, a site-specific RBSL for the construction worker was used for this evaluation.

RBSLs derived for construction worker exposures to groundwater are presented in Table 2. The RBSLs were calculated using USEPA-derived exposure factors and equations, as well as site-specific inputs where appropriate using the USEPA Regional Screening Levels (RSLs) calculator (USEPA, 2020c). The RBSL presented is the lower of the noncancer RBSL at a target noncancer hazard index of 1 and the RBSL calculated for a target cancer-based risk of 1 in 100,000, in accordance with KDHE guidance (KDHE, 2015). The target risk range is a one in one hundred thousand chance of developing cancer as the result of a specific exposure. To place this risk range in perspective, the American Cancer Society (ACS) estimates that the lifetime probability of contracting cancer in the United States is 1 in 2 for men and 1 in 3 for women (ACS, 2021). The RSL calculator output, including the exposure parameters used, is provided in Attachment A.

4.3 SCREENING LEVELS FOR THE PROTECTION OF SURFACE WATER

The GWPS and construction worker RBSLs are specific to the evaluation of groundwater at the CCR Rule monitoring wells. Based on the CSM, it was assumed that constituents in groundwater could potentially move to surface water either in Baldwin Creek or in the Kansas River where exposures could occur. To account for this potential transport pathway, Haley & Aldrich calculated site-specific groundwater screening levels to be protective of surface water for both human health and ecological exposures to surface water. To do this, the first step is to identify the relevant human health and ecological screening levels for surface water based on its uses; these screening levels are discussed in this section. In the second step, a surface water dilution and attenuation factor (SW-DAF) is developed to describe the dilution that occurs if groundwater moves to surface water; this step is described in detail in Section 5.3.

Based on the CSM presented in Section 2.1 and Figure 2, this section outlines the risk-based human health and ecological surface water screening levels that are protective of surface water in the Kansas River and Baldwin Creek.

Published numeric surface water screening levels do not apply to Baldwin Creek under KDHE's Surface Water Quality Standards guidance[1] (KDHE, 2018). Therefore, published numeric surface water criteria are not used to evaluate potential exposure to Baldwin Creek surface water. However, it is assumed that Baldwin Creek can be used for wading and site-specific RBSLs for a Baldwin Creek recreational wader scenario were developed by Haley & Aldrich and are discussed in Section 4.3.3. Evaluating recreational use of Baldwin Creek is conservative because the portion of Baldwin Creek adjacent to the Ash Ponds is owned by Evergy, therefore, it is unlikely that recreational activities would occur in the adjacent creek. Additionally, this portion of Baldwin Creek is near the confluence with the Kansas River.

Human health screening levels for surface water are identified for the following exposure settings:

1. use of Kansas River surface water as a drinking water source,
2. the consumption of fish from the Kansas River, and
3. recreational uses of surface water for the Kansas River and Baldwin Creek.

It was assumed that construction workers would not contact surface water during excavation activities. The site-specific construction worker RBSLs discussed in Section 4.2 are directly compared to groundwater monitoring well concentrations in Section 5.2.

4.3.1 Drinking Water Screening Levels

The human health screening levels for drinking water are from Kansas and USEPA sources and address the drinking water exposure pathway. The Kansas criteria for domestic water supply are the same as the Federal primary drinking water standards (MCLs). USEPA risk-based RSLs (USEPA, 2020a) for tapwater (drinking water, or untreated groundwater used as potable water) have also been included for constituents which do not have promulgated KDHE/MCL criteria. The tapwater RSLs are based on USEPA default assumptions for residential exposure to tapwater. These sources, in the order in which they were used, are:

- Kansas Surface Water Quality Standards. Kansas Department of Health and Environment Bureau of Water. April 11, 2018. Article 16. Kansas Surface Water Quality Standards - Tables of Numeric Criteria. Table 1a. Aquatic Life, Agriculture, And Public Health Designated Uses Numeric Criteria. Values for Domestic Water Supply. (KDHE, 2018)
- USEPA. Office of Water, Health Advisory Program. 2018 Edition of the Drinking Water Standards and Health Advisories. (USEPA, 2018a)
- USEPA. Regional Screening Levels, November 2020. Values for tapwater. (USEPA, 2020a)

Screening levels for human health drinking water are provided in Table 3.

[1] Based on Baldwin Creek's designation as "expected aquatic life use" defined as containing habitat types and indigenous biota commonly found or expected in the state and critical low flow of less than 0.03 cubic meter per second (1.0 cubic foot per second) (KDHE, 2013; K.A.R. 28-16-28(c)(1), KDHE, 2018). Baldwin Creek can be assumed to not provide "important refuges for aquatic life" or "permit biological recolonization of intermittently flowing segments", because the critical low flow in Baldwin Creek is less than 0.03 cubic meter per second.

4.3.2 Published Recreational Screening Levels

Published human health screening levels for surface water are generally derived to be protective of the use of surface water as a drinking water source and the consumption of fish from a surface water body. The drinking water screening levels are also protective of, but highly conservative for, recreational uses of a surface water body (such as swimming or boating) because drinking water exposure is of a higher magnitude and frequency. The drinking water screening levels used to evaluate surface water, as discussed above, are protective for other recreational uses of the river such as swimming, wading, and boating. Note that this evaluation of other uses of surface water is above and beyond the requirements of the CCR Rule and is presented in order to comprehensively evaluate potential impacts on human health or ecological receptors from constituents present in groundwater resulting from coal ash management practices at the Ash Ponds.

The human health screening levels that address use of surface water as drinking water are the values for drinking water provided in Table 3.

Values that address the fish consumption pathway are the Kansas and USEPA values for surface water, and are also provided in Table 3. These sources, in the order in which they were used, are:

- Kansas Surface Water Quality Standards. Kansas Department of Health and Environment Bureau of Water. April 11, 2018. Article 16. Kansas Surface Water Quality Standards - Tables of Numeric Criteria. Table 1a. Aquatic Life, Agriculture, And Public Health Designated Uses Numeric Criteria. Values for “Food procurement use”, which are for the use of surface waters for obtaining edible forms of aquatic or semiaquatic life for human consumption. (KDHE, 2018)

- USEPA Ambient Water Quality Criteria for Human Health Consumption of Organisms. (USEPA, 2020b)

4.3.3 Calculated Recreational Risk-Based Screening Levels

Site-specific RBSLs are essentially refined screening levels to account for receptor population characteristics and exposure pathways. As such, the site-specific RBSLs are more realistic for evaluation of potential exposures to surface water than the published screening levels discussed above and, therefore, are useful for evaluating whether constituents may have the potential to pose health risks in excess of risk thresholds. For example, whereas surface water that is used as a recreational water body for swimming could be evaluated using drinking water standards which assume that people are drinking and bathing in the water daily, site-specific RBSLs for surface water will reflect incidental ingestion and dermal contact at an exposure rate and magnitude commensurate with periodic swimming activities.

Potential exposures to constituents in surface water could, in general, occur through ingestion and dermal contact. However, the specific nature of the potential exposures is dependent on the type of water body. Specifically:

- Incidental ingestion and dermal contact with shallow surface water (e.g., less than two feet in depth) can only occur via wading because the water is not deep enough to permit swimming. Wading exposures could potentially occur in near-shore or shallow water areas of Baldwin Creek and the Kansas River.

- Incidental ingestion and dermal contact with deeper surface water (e.g., more than three feet in depth) could occur via swimming. Exposures during swimming could be potentially complete in the Kansas River; the water intermittently present in Baldwin Creek is not deep enough to allow for swimming.
- Dermal contact with surface water could occur during boating or fishing activities in the Kansas River. Since these types of activities are not associated with intense exposures to water (such as is the case with swimming), incidental ingestion of surface water would be insignificant.

RBSLs derived for recreational exposures to Kansas River surface water for a recreational swimmer, wader, and boater are presented in Table 4. RBSLs derived for recreational exposure to Baldwin Creek surface water for a recreational wader are presented in Table 5. The RBSLs were calculated using USEPA-derived exposure factors and equations, as well as site-specific inputs where appropriate using the USEPA RSL calculator (USEPA, 2020c). The RBSL presented is the lower of the noncancer RBSL at a target noncancer hazard index of 1 and the RBSL calculated for a target cancer-based risk of 1 in 100,000, in accordance with KDHE guidance (KDHE, 2015). The target risk range is a 1 in 100,000 chance of developing cancer as the result of a specific exposure. To place this risk range in perspective, the ACS estimates that the lifetime probability of contracting cancer in the United States is 1 in 2 for men and 1 in 3) for women (ACS, 2021). The RSL calculator output, including the exposure parameters used, is provided in Attachment A.

4.4 ECOLOGICAL SCREENING LEVELS

Ecological screening levels for surface water are published to provide a conservative estimate of the concentration to which an ecological receptor can be exposed without experiencing adverse effects. Due to the conservative methods used to derive published reference screening levels, it can be assumed with reasonable certainty that concentrations at or below screening levels will not result in adverse effects to survival, growth and/or reproduction. Concentrations above published ecological screening levels for surface water, however, do not necessarily indicate that a potential ecological risk exists, but rather that further evaluation may be warranted.

Table 6 presents the published ecological risk-based screening levels for surface water. Some of the screening levels are based on the hardness of the water, a default hardness value of 100 milligrams per liter (mg/L) has been used, in accordance with USEPA guidance. Note that this ecological evaluation of surface water is above and beyond the requirements of the CCR Rule and is presented in order to comprehensively evaluate potential impacts on ecological surface water receptors from constituents present in groundwater resulting from coal ash management practices at the Ash Ponds.

Water quality criteria are concentrations calculated from controlled laboratory tests on freshwater or marine organisms that are protective of the most sensitive organism (often zooplankton such as daphnids) for the most sensitive life stage (typically reproduction). As discussed in Section 4.3, these screening levels are applicable to the Kansas River, but not to Baldwin Creek. The ecological risk-based criteria for surface water, in the order in which they were used are:

- Kansas Surface Water Quality Standards. Kansas Department of Health and Environment Bureau of Water. April 11, 2018. Article 16. Kansas Surface Water Quality Standards - Tables of Numeric Criteria. Tables 1a and 1b. Surface Water Quality Standards for metals apply to total recoverable concentrations. (KDHE, 2018)

- USEPA Ambient Water Quality Criteria Freshwater Chronic and Acute. (USEPA, 2020d)

4.5 SELECTED SCREENING LEVELS

Table 7 presents the selected human health and ecological screening levels (from Tables 3, 4 and 6) for the human health drinking water, human health recreational, and ecological exposure scenarios potentially applicable to the Kansas River. The selected screening levels for Baldwin Creek are the recreational wader RBSLs derived for Baldwin Creek surface water presented on Table 5.

5. Results

The level of analysis and comparison to risk-based screening levels presented below is above and beyond the requirements of the CCR Rule. The CCR Rule requires that groundwater quality downgradient of an ash pond be evaluated in the context of drinking water standards. However, where groundwater is not used as a source of drinking water, which is the case with the Ash Ponds, then this comparison provides no information on the potential impact that constituents in groundwater may have to human health and the environment. Thus, it is also important to consider whether groundwater quality may pose a health risk of concern for the exposure pathways that may actually be complete (i.e., from a source to a receptor). This risk evaluation supplements the "Annual Groundwater Monitoring and Corrective Action Report" by providing an evaluation of potential risks associated with potentially complete exposure pathways to groundwater.

5.1 SHALLOW ALLUVIAL AQUIFER GROUNDWATER – CCR RULE EVALUATION

Evergy has filed reports and notifications on its website, as required by the federal CCR Rule, as noted above, and additional reports will be prepared and posted on Energy's website per the CCR Rule. The statistical analysis of the Ash Ponds monitoring well data completed in July 2019 indicated a statistically significant increase (SSI) for a subset of the Appendix III parameters identified in Section 3: boron, calcium, chloride, fluoride, sulfate, and total dissolved solids. The Appendix III statistical analysis results, followed by an unsuccessful Alternate Source Demonstration (ASD) for the Appendix III constituents, moved the groundwater sampling into the Assessment Monitoring phase.

Groundwater data from samples collected from the shallow alluvial aquifer groundwater were compared to the site-specific GWPS required by the CCR Rule. Figure 1 shows that the monitoring wells are all located at the edge of the Ash Ponds and, therefore, provide worst-case groundwater results. Based on the assessment monitoring results from the March 2020 semi-annual monitoring sampling event, concentrations of only four constituents, arsenic, fluoride, lithium, and molybdenum, of the 15 Appendix IV constituents analyzed in the downgradient wells are statistically above the GWPS. These measured concentrations are then referred to as Statistically Significant Levels (SSLs). Therefore, the Assessment of Corrective Measures phase of the CCR Rule is triggered for these Appendix IV constituents.

An ASD addressing the SSL for fluoride has to date been completed and certified by a qualified professional engineer. The ASD demonstrated that the source of fluoride resulting in an SSL at MW-38, downgradient of the former Ash Ponds, is natural groundwater quality variability and is associated with natural background conditions rather than an indication of groundwater quality associated with the LEC former Ash Ponds. Documentation supporting the ASD, along with the professional engineer's certification, will be provided in the 2020-2021 Annual Groundwater Monitoring and Corrective Action Reports as required by 40 Code of Federal Regulations §257.95(g)(3)(ii).

Table 1 compares the results of all CCR monitoring well sampling rounds to the GWPS. The vast majority of the results indicate concentration levels below the site-specific GWPS. A limited number of parameters are above the GWPS for some, but not all, sampling events.

The analysis shown in Table 1 demonstrates how few CCR monitoring well results are above a conservative GWPS based on drinking water MCLs, health-based GWPS, or background levels, given that the wells are located immediately adjacent to the base of the ash management area, and the facility has been in operation for over 80 years. Out of the 851 groundwater analyses conducted, only 134 results are above the GWPS (see Table 1). Put another way, approximately 84 percent of the groundwater results for the CCR Rule monitoring wells located at the edge of the Ash Ponds (MW 38, MW 39, MW-40, MW-K, and MW-L) are below the GWPS. Even for the very few results that are above screening values for some of the sampling events, including the SSI results identified under the CCR Rule, there is no complete drinking water exposure pathway to groundwater. Without the complete drinking water exposure pathway, there is no drinking water risk.

The SSI and SSL values reflect a statistical evaluation that mathematically compares the results of the various rounds of samples to background water quality and GWPS as required under the CCR Rule. However, such values without further evaluation do not establish that there is an actual adverse impact to human health or the environment. The CSM process and screening analysis described in this report provide the relevant context for such groundwater monitoring results and whether the Ash Ponds pose a true risk to human health and the environment. As explained in the remaining sections of this report, based upon the application of risk assessment principles uniformly adopted by USEPA, no such risk exists.

5.2 EVALUATION OF CONSTRUCTION WORKER EXPOSURE TO GROUNDWATER

Depth to groundwater in the area of the Ash Ponds ranges from approximately 8 feet to greater than 20 feet. Because groundwater in some areas is shallow (less than 10 feet deep), construction workers at LEC performing intrusive excavation activities in the future could potentially contact groundwater during a short-term construction/excavation event. While this would be unlikely since heavy equipment is used for such work, the nature of this contact with groundwater has been assumed for discussion and evaluation purposes; such contact would be incidental (e.g., getting groundwater on the hands and arms). Risk-based screening levels for groundwater were developed as discussed in Section 4.2 to be protective of incidental contact by construction workers.

Table 8 presents the Construction Worker RBSLs (from Table 2) and the maximum groundwater concentration of each constituent in the downgradient Ash Ponds monitoring wells. As shown on Table 8, the maximum concentrations in the downgradient Ash Ponds monitoring wells are below the construction worker RBSLs. The use of constituent concentrations from among all downgradient Ash Ponds monitoring wells is conservative because these wells are located at the edges of the Ash Ponds and the depth to water at some of the wells is deeper than would be reasonably contacted by a construction worker during a short-term construction/excavation event (depth to groundwater is greater than 20 feet in some areas).

5.3 DEVELOPMENT AND APPLICATION OF A GROUNDWATER TO SURFACE WATER DILUTION ATTENUATION FACTOR – KANSAS RIVER

LEC is located on the Kansas River – a major river system with a massive and rapid river flow. This section illustrates how the groundwater – which is a fraction of the volume and flow rate of the river – may interact with the Kansas River under an assumed set of criteria and conditions (see Attachment B). Such an exercise in assumptions can help put in context whether a theoretical risk to river water and its uses exists.

Impacts to groundwater do not mean that surface waters are impaired. The degree of interface between groundwater and surface waters is variable and complex and dependent upon a variety of factors including gradient and flow rate. It is possible, however, to determine the maximum concentration level that would need to be present on-site in groundwater and still be protective of the surface water environment, assuming gradient and flow rates are such that groundwater flows into the surface water. Groundwater and surface waters flow at very different rates and volumes. The Kansas River is a large river system in North America with an approximate flow rate of 17,000,000 cubic feet per day on average, while the groundwater at the LEC flows at a rate of between approximately 5,000 and 17,000 cubic feet per day, thus, dilution can be considerable.

It is possible to calculate a screening level for groundwater that is protective of potential surface water uses by combining the target surface water screening levels, as identified in Section 4, with an estimate of the amount of dilution that occurs between groundwater and surface water. This estimate of the groundwater-to-surface water dilution is referred to as the surface water dilution and attenuation factor (SW-DAF). The development of the SW-DAF for the Kansas River is provided in Attachment B. The calculated SW-DAF is 1,026, i.e., as groundwater flows into the river, it is diluted by more than 1,026 times. By applying the SW-DAF to the surface water screening levels, the resulting risk-based screening levels for groundwater can be used to determine whether an on-site groundwater concentration level is protective of the river. Stated differently, this is the minimum concentration level that groundwater entering the river system may pose a potential human health or ecological risk.

As discussed in the conceptual site model (Section 2.1), the Kansas River is a supply source for drinking water, and it is assumed that the Kansas River can be used for human recreation – wading, swimming, boating, fishing. It is also assumed that the river serves as habitat for aquatic species – fish, amphibians, etc. Therefore, human health drinking water screening levels, human health recreational screening levels, and ecological screening levels are used in the Kansas River evaluation.

Table 9 is summarized in the table below and shows the application of the dilution factor to calculate risk-based groundwater screening levels that are protective for surface water, for Appendix III and Appendix IV constituents with risk-based screening levels available. For each constituent, the selected human health drinking water and recreational screening levels, as well as the ecological screening levels (from Table 7) are presented. The lowest of the three screening levels is then identified for surface water. The SW-DAF is then applied to this lowest screening level for surface water to result in the groundwater screening level that is protective for human and ecological uses of surface water, as shown in Table 9 and in the table below.

This evaluation is not limited to only those constituents for which SSIs or SSLs have been identified. The constituents listed in Table 9 are those for which there is one or more detected groundwater results with available risk-based screening levels.

The groundwater risk-based screening levels are calculated in units of mg/L. One mg/L is equivalent to one part per million.

Table 9 and the table below identify the maximum groundwater concentration of each constituent detected in the Ash Ponds monitoring wells. The comparison between the target levels and the maximum concentrations indicates that there is a wide margin of safety between the two values. This margin is shown in the last column of the table. To illustrate, concentration levels of arsenic, lithium and molybdenum would need to be more than 18, 460, and more than 440 times higher, respectively, than currently measured levels before an adverse impact in the river could potentially occur.

CALCULATING RISK-BASED SCREENING LEVELS FOR GROUNDWATER (see Table 9)

Dilution Attenuation Factor for Kansas River (See Attachment B for derivation):		1,026				
Constituent	**Lowest of the Human Health and Ecological Screening Levels (mg/L)**	**Target Groundwater Screening Level - Kansas River (mg/L)**	**Maximum Groundwater Concentration - Ash Ponds (mg/L)**		**Is Maximum Groundwater Concentration Above the Target Groundwater Screening Level?**	**Ratio Between Target Groundwater Screening Level and the Maximum Groundwater Concentration**
Detection Monitoring - USEPA Appendix III Constituents						
Boron	4	4,104	7.4	MW-40	No	>550
Fluoride	2	2,052	5.5	MW-38	No	>370
Assessment Monitoring - USEPA Appendix IV Constituents						
Antimony	0.006	6	<0.0010		ND	ND
Arsenic	0.0014	1.44	0.076	MW-K	No	>18
Barium	2	2,052	0.094	MW-L	No	>21,000
Beryllium	0.004	4.10	<0.0010		ND	ND
Cadmium	0.00027	0.28	<0.00050		ND	ND
Chromium (Total)	0.074	76	<0.00050		ND	ND
Cobalt	0.006	6.2	0.0028	MW-K	No	>2,100
Lead	0.0025	2.6	<0.010		ND	ND
Lithium	0.04	41	0.089	MW-K	No	>460
Mercury	0.000146	0.150	<0.00020		ND	ND
Molybdenum	0.1	103	0.23	MW-39	No	>440
Selenium	0.0031	3	<0.0010		ND	ND
Thallium	0.002	2.05	<0.0010		ND	ND
Radiological (pCi/L)						
Radium-226 & 228	5	5,130	2.73	MW-K	No	>1,800

*** Where the Groundwater Risk-Based Screening Level = Screening Level x Dilution Factor.**
ND = not detected.
pCi/L = pico-Curies per liter.

This means that not only do the current concentrations of constituents in groundwater at the Ash Ponds not pose a risk to human health or the environment, but even much higher concentrations in groundwater would not be harmful.

5.4 EVALUATION OF RECREATIONAL WADER EXPOSURE TO SURFACE WATER – BALDWIN CREEK

As presented in the April 25th, 2000 report “Engineering Investigation of the Earthen Lagoons at the Lawrence Energy Center Phase II” prepared by Geotechnical Services, Inc., during portions of the year, Baldwin Creek has very low flow and is reported as being stagnant (below the detectable level of the flow meter). Therefore, a dilution attenuation factor was not calculated for Baldwin Creek and the maximum concentrations observed in the groundwater monitoring well network were used for comparison to screening levels.

Human health recreational wading screening levels, as discussed in Section 4.3.3, are used to evaluate potential human exposure to Baldwin Creek, as it is assumed that Baldwin Creek can be used recreationally and that the small size and periodic drying of the creek would limit its recreational use mostly to wading. Ecological screening levels were not used to evaluate potential exposures to Baldwin Creek because, as discussed in the conceptual site model (Section 2.1), it is assumed that Baldwin Creek's small size and periodic drying would limit its ability to support a consumptive fishery or habitat for aquatic species.

Table 10 presents the Recreational Wader RBSLs for Baldwin Creek (from Table 5) and the maximum groundwater concentration of each constituent in the downgradient Ash Ponds monitoring wells. As shown on Table 10, the maximum concentrations in all downgradient Ash Ponds monitoring wells are below the Recreational Wader RBSLs for Baldwin Creek.

This comparison is the most conservative estimate of the potential risk associated with Recreational Wader exposure to surface water in Baldwin Creek as the screened concentrations are present in wells that are located at the edges of the Ash Ponds and do not factor in the groundwater flux at the river edge (land and river interface) and subsequent mixing with surface water. It is assumed that the actual condition in Baldwin Creek even under low flow conditions would exhibit lower concentrations and, therefore, be even more protective of human health and the environment.

6. Summary

This comprehensive evaluation demonstrates that there are no adverse impacts on human health or ecological receptors from constituents present in groundwater resulting from coal ash management practices at the Ash Ponds at the Lawrence Energy Center, as summarized in the following supporting conclusions from the risk evaluation:

- The majority (84 percent) of CCR monitoring well analytical results are below GWPS (i.e., below drinking water standards).
- Even for the very few results that may be above screening values for some of the groundwater sampling events, there are no on-site or downgradient users of groundwater as drinking water. Where there is no current or reasonably anticipated future drinking water exposure, there is no risk.
- All CCR monitoring well analytical results are below site-specific construction worker RBSLs. Therefore, there is no unacceptable health risk for construction workers who could potentially contact shallow groundwater while performing excavation activities.
- Groundwater concentrations at the Ash Ponds are below conservative risk-based screening levels protective of people who use the Kansas River as a source of drinking water, for recreational purposes, and for ecological receptors that live in or use the Kansas River. The risk evaluation demonstrates that groundwater concentrations could be much higher than they are now before groundwater could hypothetically cause a CCR-related constituent in Kansas River surface water to be above a screening level.
- All CCR monitoring well analytical results are below human health recreational wader screening levels for Baldwin Creek. Therefore, there is no unacceptable health risk for recreational receptors who could potentially contact Baldwin Creek surface water while wading. It is assumed that Baldwin Creek's small size and periodic drying would limit its ability to support a consumptive fishery or habitat for aquatic species, therefore ecological receptors were not evaluated for Baldwin Creek.

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TABLES

TABLE 1
COMPARISON OF ASH PONDS GROUNDWATER MONITORING RESULTS TO SITE GROUNDWATER PROTECTION STANDARDS –
LAWRENCE ENERGY CENTER - ASH PO
LAWRENCE, KANSAS

Monitoring Well ID		Sample Name	Sample Date	Depth to Water (btoc)	Detection Monitoring - USEPA Appendix III Constituents						Appendix III/ Appendix IV	Assessment Monitoring - USEPA Appendix IV Constituents													
					Boron, Total	Calcium, Total	Chloride	Sulfate	pH	TDS	Fluoride	Antimony, Total	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Chromium, Total	Cobalt, Total	Lead, Total	Lithium, Total	Molybdenum, Total	Selenium, Total	Thallium, Total	Mercury, Total	Radium-226 & 228
					mg/L	mg/L	mg/L	mg/L	SU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L
				Site GWPS (b)	NA	NA	NA	NA	NA	NA	4.0	0.006	0.01	2	0.004	0.005	0.1	0.006	0.015	0.04	0.149	0.05	0.002	0.002	5
Upgradient	MW-37	MW-37-030718	3/7/2018	10.04	2.2	134	27.2	335	7.3	735	0.37	<0.0010	0.0047	0.045	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.013	0.13	<0.0010	<0.0010	<0.00020	0.641
		MW-37-050918	5/9/2018	11.1	2.2	138	31.1	355	7.2	776	0.36	<0.0010	0.0077	0.055	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.014	0.14	<0.0010	<0.0010	<0.00020	0.794
		MW-37-070218	7/2/2018	12.32	2.2	136	29	293	7.7	753	0.36	<0.0010	0.0056	0.048	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.015	0.14	<0.0010	<0.0010	<0.00020	1.12
		MW-37-081418	8/14/2018	14.38	2.1	135	29.4	294	7.2	759	0.41	<0.0010	0.0045	0.046	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.011	0.13	<0.0010	<0.0010	<0.00020	1.45
		MW-37-100318	10/3/2018	14.54	2.2	140	29.7	371	7.4	751	0.32	<0.0010	0.0053	0.05	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.017	0.13	<0.0010	<0.0010	<0.00020	0.561
		MW-37-111918	11/19/2018	11.39	2	143	29.7	275	7.2	3120	0.44	<0.0010	0.0054	0.051	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.01	0.13	<0.0010	<0.0010	<0.00020	0.449
		MW-37-011119	1/11/2019	8.51	2.1	140	28.8	283	7.4	722	0.28	<0.0010	0.0089	0.058	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.018	0.14	<0.0010	<0.0010	<0.00020	1.1
		MW-37-031819	3/18/2019	7.33	1.9	138	33.5	297	7.2	734	0.38	<0.0010	0.0074	0.054	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.018	0.13	<0.0010	<0.0010	<0.00020	1.15
		MW-37	9/4/2019	6.55	1.75	134	33.6	287	7.2	775	0.35														
		MW-37-120619	12/6/2019	9.61	-	-	-	-	-	-	0.27	<0.0010	0.0078	0.061	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.017	0.14	<0.0010	<0.0010	<0.00020	0.0414 +/- 0.563 (0.967)
		MW-37-031020	3/10/2020	6.79	2	172	40.6	319	7	853	0.27	-	0.0065	0.065	-	-	-	-	-	0.018	0.12	-	-	-	
		MW-37-091520	9/15/2020	11.6	2.1	195	46.5	360	7.1	930	< 0.20	-	0.0086	0.079	-	-	-	-	-	0.019	0.11	-	-	-	2.56 +/- 1.14 (1.18)
		MW-37-120120	12/1/2020	13.36	-	-	-	-	-	-	-	< 0.0010	0.0045	0.07	< 0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.019	0.11	<0.0010	<0.0010	<0.00020	
Downgradient	MW-38	MW-38-030718	3/7/2018	16.11	6.2	319	220	1390	7.6	2230	5	<0.0010	0.015	0.038	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.079	0.1	<0.0010	<0.0010	<0.00020	1.56
		MW-38-050918	5/9/2018	15.98	6	312	237	1470	7.5	2520	5	<0.0010	0.014	0.037	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.083	0.093	<0.0010	<0.0010	<0.00020	0.864
		MW-38-070218	7/2/2018	16.43	5.8	300	254	1560	7.7	2480	5.1	<0.0010	0.013	0.034	<0.0010	<0.00050	<0.00050	<0.0010	<0.010	0.077	0.099	<0.0010	<0.0010	<0.00020	1.88
		MW-38-081418	8/14/2018	16.84	5.7	312	206	1300	7.5	2250	5.5	<0.0010	0.013	0.034	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.072	0.087	<0.0010	<0.0010	<0.00020	0.377
		MW-38-100318	10/3/2018	16.69	5.6	309	250	1370	7.6	461	5.3	<0.0010	0.014	0.032	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.076	0.089	<0.0010	<0.0010	<0.00020	0.136
		MW-38-111918	11/19/2018	14.56	4.9	320	206	1220	7.5	1400	4.8	<0.0010	0.014	0.032	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.071	0.087	<0.0010	<0.0010	<0.00020	0.951
		MW-38-011119	1/11/2019	14.14	5.4	322	202	1210	7.6	2600	4.7	<0.0010	0.014	0.032	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.076	0.088	<0.0010	<0.0010	<0.00020	0.862
		MW-38-031919	3/19/2019	14.29	5.2	302	199	1350	7.5	2140	4.7	<0.0010	0.015	0.031	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.076	0.094	<0.0050	<0.0010	<0.00020	1.78
		MW-38	9/4/2019	10.65	4.7	292	201	1220	7.4	2440	2														
		MW-38-120619	12/6/2019	14.04	-							<0.0010	0.015	0.031	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.075	0.092	<0.0010	<0.0010	<0.00020	1.84 +/- 0.756 (1.08)
		MW-38-031020	3/10/2020	14.93	5.39	336	249	1290	7.6	2460	4.6	-	0.015	0.0334	-	-	-	-	-	0.0744	0.0822	-	-	-	
		MW-38-091520	9/15/2020	16.53	5.5	315	237	1380	7.5	2640	2.8	-	0.029	0.04	-	-	-	-	-	0.071	0.074	-	-	-	0.656 +/- 0.534 (0.865)
		MW-38-120120	12/1/2020	16.61	-	-	-	-	-	-	-	<0.0010	0.019	0.036	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.084	0.081	<0.0010	<0.0010	<0.00020	
	MW-39	MW-39-030818	3/8/2018	15.6	5.5	478	357	1920	7.3	3090	2.7	<0.0010	0.012	0.031	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.038	0.11	<0.0010	<0.0010	<0.00020	0.966
		MW-39-050918	5/9/2018	14.97	5.4	490	375	1870	7.3	3400	2.9	<0.0010	0.013	0.033	<0.0010	<0.00050	<0.0050	0.0011	<0.010	0.05	0.11	<0.0010	<0.0010	<0.00020	0.795
		MW-39-070218	7/2/2018	15.4	5.3	478	487	2110	7.5	3390	3.3	<0.0010	0.013	0.032	<0.0010	<0.00050	<0.0050	0.0014	<0.010	0.049	0.11	<0.0010	<0.0010	<0.00020	1.47
		MW-39-081418	8/14/2018	15.69	5.5	511	403	1750	7.1	3550	3	<0.0010	0.013	0.032	<0.0010	<0.00050	<0.0050	0.0016	<0.010	0.047	0.093	<0.0010	<0.0010	<0.00020	1.05
		MW-39-100318	10/3/2018	15.41	5.4	493	535	1940	7.2	3550	3.2	<0.0010	0.013	0.033	<0.0010	<0.00050	<0.0050	0.0014	<0.010	0.049	0.089	<0.0010	<0.0010	<0.00020	0.582
		MW-39-111918	11/19/2018	12.74	4.3	486	443	1880	7.4	3640	3.5	<0.0010	0.014	0.032	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.062	0.14	<0.0010	<0.0010	<0.00020	1.23
		MW-39-011119	1/11/2019	12.21	4.8	510	373	1730	7.2	3770	2.9	<0.0010	0.01	0.03	<0.0010	<0.00050	<0.0050	0.0013	<0.010	0.043	0.11	<0.0010	<0.0010	<0.00020	0.782
		MW-39-031919	3/19/2019	12.65	4.6	490	399	1810	7.3	3480	1.9	<0.0010	0.011	0.03	<0.0010	<0.00050	<0.00050	0.0012	<0.010	0.045	0.15	<0.0050	<0.0010	<0.00020	1.62
		MW-39	9/4/2019	8.84	4.46	464	334	1780	7.2	3480	<0.20														
		MW-39-120619	12/0619	11.49								<0.0010	0.014	0.03	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.045	0.19	<0.0010	<0.0010	<0.00020	0.760 +/- 0.619 (1.01)
		MW-39-031120	3/11/2020	13.7	5	576	317	1730	7.2	3370	2.2	-	0.0112	0.0338	-	-	-	-	-	0.038	0.179	-	-	-	
		MW-39-091520	9/15/2020	15.5	4.9	588	376	1870	7.2	3570	1.8	-	0.011	0.034	-	-	-	-	-	0.037	0.23	-	-	-	0.923 +/- 0.562 (0.971)
		MW-39-101920	10/19/2020	15.65	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.23	-	-	-	-
		MW-39-120120	12/1/2020	15.38	-	-	-	-	-	-	-	<0.0010	0.013	0.034	<0.0010	<0.00050	<0.0050	0.0011	<0.010	0.039	0.2	<0.0010	<0.0010	<0.00020	
	MW-40	MW-40-030818	3/8/2018	16.17	7.4	526	410	1930	7	3180	1.6	<0.0010	0.013	0.037	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.046	0.14	<0.0010	<0.0010	<0.00020	1
		MW-40-050918	5/9/2018	15.6	7.2	527	412	1890	7	3300	1.9	<0.0010	0.014	0.039	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.056	0.15	<0.0010	<0.0010	<0.00020	0.277
		MW-40-070218	7/2/2018	16.01	7	487	429	2160	7	3190	2.1	<0.0010	0.014	0.036	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.052	0.19	<0.0010	<0.0010	<0.00020	0.633
		MW-40-081418	8/14/2018	16.25	6.9	506	331	1770	7	3310	1.9	<0.0010	0.014	0.035	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.048	0.16	<0.0010	<0.0010	<0.00020	0.9
		MW-40-100318	10/3/2018	16.01	6.7	512	356	1830	7	3230	2	<0.0010	0.014	0.036	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.053	0.16	<0.0010	<0.0010	<0.00020	0.184
		MW-40-111918	11/19/2018	13.43	6.1	536	351	1780	7	3100	1.7	<0.0010	0.027	0.035	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.047	0.062	<0.0010	<0.0010	<0.00020	0.81
		MW-40-011119	1/11/2019	12.72	6.4	504	306	1610	7	3100	1.5	<0.0010	0.014	0.034	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.045	0.15	<0.0010	<0.0010	<0.00020	0.481
		MW-40-031919	3/19/2019	13.25	5.8	468	329	1730	7.2	3060	1.2	<0.0010	0.015	0.033	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.049	0.15	<0.0050	<0.0010	<0.00020	1.26
		MW-40	9/4/2019	9.38	5.45	488	309	1650	7.2	3160	<0.20														
		MW-40-120619	12/6/2019	11.96								<0.0010	0.015	0.031	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.045	0.11	<0.0010	<0.0010	<0.00020	0.912 +/- 0.613 (0.929)
		MW-40-031120	3/11/2020	14.38	4.93	464	289	1490	7.2	3090	1.6	-	0.014	0.0321	-	-	-	-	-	0.0415	0.0959	-	-	-	
		MW-40-091520	9/15/2020	15.96	5.1	458	273	1750	7.2	2660	< 0.20	-	0.014	0.034	-	-	-	-	-	0.038	0.079	-	-	-	1.26 +/- 0.629 (0.970)
		MW-40-120120	12/1/2020	15.95	-	-	-	-	-	-	-	<0.0010	0.014	0.034	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.044	0.076	<0.0010	<0.0010	<0.00020	
	MW-K	MW-K-050918	5/10/2018	26.35	3.6	504	481	1570	7.2	3580	3.4	<0.0010	0.075	0.052	<0.0010	<0.00050	<0.0050	0.0028	<0.010	0.051	0.04	<0.0010	<0.0010	<0.00020	0.866
		MW-K-070218	7/2/2018	26.77	3.1	473	593	2020	7.7	3350	3.5	<0.0010	0.07	0.042	<0.0010	<0.00050	<0.0050	0.0015	<0.010	0.067	0.032	<0.0010	<0.0010	<0.00020	1.6
		MW-K-081418	8/14/2018	27.18	2.9	482	516	1650	7.3	3740	0.76	<0.0010	0.073	0.041	<0.0010	<0.00050	<0.0050	0.0016	<0.010	0.063	0.027	<0.0010	<0.0010	<0.00020	2.73
		MW-K-100318	10/3/2018	27	2.9	513	708	1940	7.1	4000	3.5	<0.0010	0.072	0.045	<0.0010	<0.00050	<0.0050	0.0014	<0.010	0.07	0.027	<0.0010	<0.0010	<0.00020	0.253
		MW-K-111918	11/19/2018	24.68	2.2	554	638	1960	7.2	3840	3.2	<0.0010	0.069	0.044	<0.0010	<0.00050	<0.0050	0.0011	<0.010	0.066	0.018	<0.0010	<0.0010	<0.00020	0.864
		MW-K-121218	12/12/2018	23.21	2.6	541	587	1920	7.2	4010	3.1	<0.0010	0.069	0.042	<0.0010	<0.00050	<0.0050	0.0015	<0.010	0.076	0.022	<0.0010	<0.0010	<0.00020	1.16
		MW-K-011119	1/11/2019	24.32	2.1	533	653	2000	7.4	4090	3	<0.0010	0.07	0.041	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.076	0.014	<0.0010	<0.0010	<0.00020	0.8
		MW-K-031919	3/19/2019	24.55	2.4	538	825	2160	7.3	4370	2.2	<0.0010	0.075	0.043	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.084	0.014	<0.0010	<0.0010	<0.00020	0.951
		MW-K	9/5/2019	20.76	1.73	568	942	2350	7.2	5490	3.7														
		MW-K-120619	12/6/2019	24.28								<0.0010	0.076	0.04	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.089	0.0096	<0.0010	<0.0050	<0.00020	0.547 +/- 0.663 (1.12)
		MW-K-031120	3/11/2020	25.4	1.77	562	944	2190	7.3	5020	2.7	-	0.0675	0.0426	-	-	-	-	-	0.0765	0.0157	-	-	-	
		MW-K-091520	9/15/2020	27.11	2.4	480	691	2040	7.3	4210	3.4	-	0.076	0.038	-	-	-	-	-	0.077	0.021	-	-	-	2.05 +/- 0.755 (1.12)
		MW-K-1201220	12/1/2020	27.05	-	-	-	-	-	-	-	<0.0010	0.067	0.038	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.065	0.023	<0.0010	<0.0050	<0.00020	
	MW-L	MW-L-050918	5/10/2018	27.24	2.6	508	486	1730	7.1	3880	2.2	<0.0010	0.021	0.094	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.044	0.038	<0.0010	<0.0010	<0.00020	1.01
		MW-L-070218	7/2/2018	27.63	2.4	511	648	2090	7.3	3690	2	<0.0010	0.022	0.055	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.038	0.043	<0.0010	<0.0010	<0.00020	1.23
		MW-L-081418	8/14/2018	27.96	1.7	546	625	1910	7	4090	1.9	<0.0010	0.02	0.047	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.045	0.039	<0.0010	<0.0010	<0.00020	1.01
		MW-L-100318	10/3/2018	27.73	1.8	561	877	2200	7.1	4340	2.1	<0.0010	0.021	0.059	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.05	0.038	<0.0010	<0.0010	<0.00020	0.253
		MW-L-111918	11/19/2018	25.17	1.7	668	860	2280	6.9	3250	1.8	<0.0010	0.024	0.05	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.051	0.041	<0.0010	<0.0010	<0.00020	2.08
		MW-L-121218	12/12/2018	23.64	1.9	624	822	2310	6.8	4900	2.1	<0.0010	0.025	0.042	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.049	0.047	<0.0010	<0.0010	<0.00020	1.16
		MW-L-011119	1/11/2019	24.68	2	651	809	2410	7.1	4350	2	<0.0010	0.025	0.043	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.046	0.047	<0.0010	<0.0010	<0.00020	1.26
		MW-L-031919	3/19/2019	25.08	2.1	612	946	2180	7.2	4710	1	<0.0010	0.026	0.039	<0.0010	<0.00050	<0.00050	<0.0010	<0.010	0.053	0.051	<0.0050	<0.0010	<0.00020	0.483
		MW-L	9/5/2019	23.03	2.26	545	624	1880	7.1	4180	<0.20														
		MW-L-120619	12/6/2019	24.78								<0.0010	0.029	0.037	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.057	0.055	<0.0010	<0.0050	<0.00020	0.482 +/- 0.632 (0.980)
		MW-L-031120	3/11/2020	26.58	2.63	551	633	1880	7.3	3880	2.4	-	0.0238	0.0352	-	-	-	-	-	0.0568	0.0495	-	-	-	
		MW-L-091520	9/15/2020	27.93	2.9	585	621	1990	7.2	3990	2.2	-	0.026	0.035	-	-	-	-	-	0.055	0.054	-	-	-	1.23 +/- 0.623 (0.962)
		MW-L-120120	12/1/2020	27.79	-	-	-	-	-	-	-	<0.0010	0.024	0.035	<0.0010	<0.00050	<0.0050	<0.0010	<0.010	0.082	0.048	<0.0010	<0.0050	<0.00020	

Notes:
Blank cells - Constituent not included in this analysis.
< - Constituent was not detected, value is the reporting limit.
btoc - Below top of casing.
GW - Groundwater.

GWPS - Groundwater Protection Standard.
mg/L - milligrams per liter.
NA - Not Available.
pCi/L - picoCurie per liter.

(a) - Site GWPS provided in the 2019-2020 Annual Groundwater Monitoring and Corrective Action Report (Haley & Aldrich, 2020).

Detected Fluoride Concentration > Groundwater Protection Standard, however this is due to natural groundwater quality variability and is associated with natural background conditions. See text for details on the derivation of the alternative source demonstration (ASD) for fluoride.
Statistically Significant Level (SSL) above the Groundwater Protection Standard.

TABLE 2
CONSTRUCTION WORKER CALCULATED RISK BASED SCREENING LEVELS FOR GROUNDWATER
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

Constituent	CAS RN	Construction Worker Calculated Groundwater RBSL (a) (mg/L)	
Detection Monitoring - USEPA Appendix III Constituents (b)			
Boron	7440-42-8	2,100	
Fluoride	16984-48-8	420	
Assessment Monitoring - USEPA Appendix IV Constituents			
Antimony	7440-36-0	0.63	
Arsenic	7440-38-2	3.15	(c)
Barium	7440-39-3	147	
Beryllium	7440-41-7	0.368	
Cadmium	7440-43-9	0.263	
Chromium (Total)	7440-47-3	205	(d)
Cobalt	7440-48-4	78.8	
Lead	7439-92-1	NA	
Lithium	7439-93-2	21	
Mercury	7439-97-6	1.47	(e)
Molybdenum	7439-98-7	630	
Selenium	7782-49-2	52.5	
Thallium	7440-28-0	0.42	
Radiological (pCi/L)			
Radium-226 & 228	7440-14-4	NA	

Notes:

CAS RN - Chemical Abstracts Service Registry Number.
NA - Not Available.
pCi/L - picoCuries/liter.
mg/L - milligrams/liter.
RBSL - Risk-Based Screening Level.
USEPA - United States Environmental Protection Agency.

(a) - Documentation for the Construction Worker Calculated Screening Level for Groundwater is provided in Attachment A.
Site-specific risk based screening levels (RBSLs) calculated using USEPA exposure factors and the
USEPA screening levels calculator (Hazard Index=1 and Target Risk=1E-05).
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search

(b) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

(c) - Arsenic RBSLs are based on the lower of the values based on a hazard index of 1 and an excess lifetime cancer risk of 1E-05.
RBSL based on noncancer endpoint (cancer-based RBSL at 1E-5 is 4.9 mg/L).
Of the constituents evaluated, arsenic is the only constituent with an RSL based on potential carcinogenic effects.

(d) - Value for chromium (III) used.

(e) - Value for mercuric chloride used.

TABLE 3
HUMAN HEALTH PUBLISHED SCREENING LEVELS FOR SURFACE WATER - KANSAS RIVER
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

		Human Health Published Screening Level - Drinking Water			Human Health Published Screening Level - Surface Water		Selected Published Human Health Screening Levels for Surface Water	
Constituent	**CAS RN**	**Kansas Domestic Water Supply Surface Water Quality Standards (a) (mg/L)**	**USEPA MCL (b) (mg/L)**	**USEPA RSL Tap Water (c) (mg/L)**	**Kansas Food Procurement Use Surface Water Quality Standards (d) (mg/L)**	**USEPA NRWQC Consumption of Organism Only (e) (mg/L)**	**Selected Screening Level - Drinking Water (f) (mg/L)**	**Selected Screening Level - Surface Water Consumption of Organism Only (g) (mg/L)**
Detection Monitoring - USEPA Appendix III Constituents (h)								
Boron	7440-42-8	NA	NA	4	NA	NA	4	NA
Fluoride	16984-48-8	2	4	0.8	NA	NA	2	NA
Assessment Monitoring - USEPA Appendix IV Constituents								
Antimony	7440-36-0	0.006	0.006	0.0078	0.64	0.64	0.006	0.64
Arsenic	7440-38-2	0.01	0.01	0.000052	0.0014 (i, k)	0.0014 (j, k)	0.01	0.0014
Barium	7440-39-3	2	2	3.8	NA	NA	2	NA
Beryllium	7440-41-7	0.004	0.004	0.025	NA	NA	0.004	NA
Cadmium	7440-43-9	0.005	0.005	0.0092	0.17	NA	0.005	0.17
Chromium (Total)	7440-47-3	0.1	0.1	22 (l)	3,433 (l)	NA	0.1	3433
Cobalt	7440-48-4	NA	NA	0.006	NA	NA	0.006	NA
Lead	7439-92-1	0.015 (m)	0.015 (m)	0.015 (m)	NA	NA	0.015	NA
Lithium	7439-93-2	NA	NA	0.04	NA	NA	0.04	NA
Mercury	7439-97-6	0.002 (p)	0.002 (n)	0.0057 (o)	0.000146 (p)	NA	0.002	0.000146
Molybdenum	7439-98-7	NA	NA	0.1	NA	NA	0.1	NA
Selenium	7782-49-2	0.05	0.05	0.1	NA	4.2	0.05	4.2
Thallium	7440-28-0	0.002	0.002	0.0002	0.0063	0.00047	0.002	0.0063
Radiological (pCi/L)								
Radium-226 & 228	7440-14-4	5	5	NA	NA	NA	5	NA

Notes:

CAS RN - Chemical Abstracts Service Registry Number.
MCL - Maximum Contaminant Level.
mg/L - milligrams/liter.
NA - Not Available.
pCi/L - picoCuries/liter.
RSL - Regional Screening Level.
USEPA - United States Environmental Protection Agency.

TABLE 3
HUMAN HEALTH PUBLISHED SCREENING LEVELS FOR SURFACE WATER - KANSAS RIVER
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

(a) - Kansas Surface Water Quality Standards. Kansas Department of Health and Environment Bureau of Water. April 11, 2018. Article 16.

Kansas Surface Water Quality Standards - Tables of Numeric Criteria. Table 1a. Aquatic Life, Agriculture, And Public Health Designated Uses Numeric Criteria.
Values for Domestic Water Supply.
https://kdheks.gov/tmdl/kswqs.htm

(b) - USEPA, 2018. 2018 Edition of the Drinking Water Standards and Health Advisories. March.
https://www.epa.gov/dwstandardsregulations/2018-drinking-water-standards-and-advisory-tables

(c) - USEPA, 2020. Regional Screening Levels (November 2020). Values for Tap Water, Hazard Index = 1.0. Target Risk = 1E-06.
https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

(d) - Kansas Surface Water Quality Standards. Kansas Department of Health and Environment Bureau of Water. April 11, 2018. Article 16.
Kansas Surface Water Quality Standards - Tables of Numeric Criteria. Table 1a. Aquatic Life, Agriculture, And Public Health Designated Uses Numeric Criteria.
"Food procurement use" means the use of surface waters for obtaining edible forms of aquatic or semiaquatic life for human consumption.
https://kdheks.gov/tmdl/kswqs.htm

(e) - USEPA National Recommended Water Quality Criteria - Human Health Criteria Table.
USEPA NRWQC - Human Health Criterion for the Consumption of Organism Only apply to total concentrations.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table

(f) - The hierarchy for selection among the Human Health Published Screening Levels for Drinking Water is:
1) Kansas Domestic Water Supply Surface Water Quality Standards
2) USEPA MCL
3) USEPA RSL - Tap Water

(g) - The hierarchy for selection among the Human Health Published Screening Values for Surface Water - Consumption of Organism Only is:
1) Kansas Food Procurement Use Surface Water Quality Standards
2) USEPA NRWQC - Consumption of Organism Only.

(h) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

(i) - Value for inorganic arsenic as arsenite, As(III).

(j) - Value for inorganic arsenic only.

(k) - This criterion adjusted to a carcinogenicity of 1E-05 risk.

(l) - Value for chromium (III).

(m) - Lead Action Level. This is a drinking water treatment action level applicable to regulated Community and Non-Transient Non-Community public water systems.
http://www.in.gov/idem/files/factsheet_owq_pws_lead_copper.pdf
https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=60001N8P.txt

(n) - Value for inorganic mercury.

(o) - Value for mercuric chloride.

(p) - Value for total mercury.

TABLE 4
HUMAN HEALTH CALCULATED RISK BASED SCREENING LEVELS FOR RECREATIONAL USE OF SURFACE WATER - KANSAS RIVER
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

Constituent	CAS RN	Human Health Calculated RBSL - Recreational Use of Surface Water - Kansas River (c): Current/Future Off-Site Recreational Swimmer Age-Adjusted (Ages 1 - 26) (a) (mg/L)		Current/Future Off-Site Recreational Wader Age-Adjusted (Ages 1 - 26) (a) (mg/L)		Current/Future Off-Site Recreational Boater (Adult) (a) (mg/L)		Selected Human Health Calculated RBSL - Recreational Use of Surface Water - Kansas River (b) (mg/L)
Detection Monitoring - USEPA Appendix III Constituents (j)								
Boron	7440-42-8	114		120		11,200		114
Fluoride	16984-48-8	22.9		23.9		2,240		22.9
Assessment Monitoring - USEPA Appendix IV Constituents								
Antimony	7440-36-0	0.171		0.218		3.36		0.171
Arsenic	7440-38-2	0.0236	(e, f)	0.0389	(e, g)	2.61	(e, h)	0.0236
Barium	7440-39-3	63.7		97.1		784		63.7
Beryllium	7440-41-7	0.121		0.345		0.784		0.121
Cadmium	7440-43-9	0.134		0.225		1.4		0.134
Chromium (Total)	7440-47-3	155	(i)	386	(i)	1,090	(i)	155
Cobalt	7440-48-4	0.178		0.181		42		0.178
Lead	7439-92-1	0.015	(j)	0.015	(j)	0.015	(j)	0.015
Lithium	7439-93-2	1.14		1.2		112		1.14
Mercury	7439-97-6	0.0956	(k)	0.146	(k)	1.18	(k)	0.0956
Molybdenum	7439-98-7	2.86		2.99		280		2.86
Selenium	7782-49-2	2.86		2.99		280		2.86
Thallium	7440-28-0	0.00572		0.00598		0.56		0.00572
Radiological (pCi/L)								
Radium-226 & 228	7440-14-4	NA		NA		NA		NA

Notes:
CAS RN - Chemical Abstracts Service Registry Number.
NA - Not Available.
pCi/L - picoCuries/liter.
mg/L - milligrams/liter.
RBSL - Risk-Based Screening Level.
USEPA - United States Environmental Protection Agency.

(a) - Documentation for the receptor-specific Human Health Calculated Screening Level for Recreational Use of Surface Water is provided in Attachment A. Site-specific risk based screening levels (RBSLs) calculated using USEPA exposure factors and the USEPA screening levels calculator (Hazard Index=1 and Target Risk=1E-05). https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search
(b) - The selected human health RBSL for recreational use of surface water is the minimum value from amongst the Current/Future Off-Site Recreational Swimmer, Current/Future Off-Site Recreational Wader, and Current/Future Off-Site Recreational Boater RBSLs.
(c) - Some calculated values may be above solubility limits.
(d) - USEPA lead action level of 0.015 mg/L for lead in drinking water (USEPA, 2018) is used as the RBSL.
(e) - Arsenic RBSLs are based on the lower of the values based on a hazard index of 1 and an excess lifetime cancer risk of 1E-05. Note that of the constituents evaluated, arsenic is the only constituent with an RSL based on potential carcinogenic effects.
(f) - RBSL based on cancer endpoint at 1E-5 (noncancer-based RBSL is 0.172 mg/L).
(g) - RBSL based on cancer endpoint at 1E-5 (noncancer-based RBSL is 0.179 mg/L).
(h) - RBSL based on cancer endpoint at 1E-05 (noncancer-based RBSL is 16.8 mg/L).
(i) - Value for chromium (III) used.
(j) - USEPA lead action level of 0.015 mg/L for lead in drinking water (USEPA, 2018) is used as the RBSL.
(k) - Value for mercuric chloride used.

TABLE 5
HUMAN HEALTH CALCULATED RISK BASED SCREENING LEVELS FOR RECREATIONAL USE OF SURFACE WATER - BALDWIN CREEK
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

Constituent	CAS RN	Current/Future Off-Site Recreational Wader - Baldwin Creek - Age-Adjusted (Ages 1 - 26) (a) (mg/L)	
Detection Monitoring - USEPA Appendix III Constituents (b)			
Boron	7440-42-8	1,030	
Fluoride	16984-48-8	207	
Assessment Monitoring - USEPA Appendix IV Constituents			
Antimony	7440-36-0	1.12	
Arsenic	7440-38-2	0.274	(c)
Barium	7440-39-3	345	
Beryllium	7440-41-7	0.463	
Cadmium	7440-43-9	0.67	
Chromium (Total)	7440-47-3	624	(d)
Cobalt	7440-48-4	1.7	
Lead	7439-92-1	0.015	(e)
Lithium	7439-93-2	10.3	
Mercury	7439-97-6	0.517	(f)
Molybdenum	7439-98-7	25.8	
Selenium	7782-49-2	25.8	
Thallium	7440-28-0	0.0517	
Radiological (pCi/L)			
Radium-226 & 228	7440-14-4	NA	

Notes:
CAS RN - Chemical Abstracts Service Registry Number.
NA - Not Available.
pCi/L - picoCuries/liter.
mg/L - milligrams/liter.
RBSL - Risk-Based Screening Level.
USEPA - United States Environmental Protection Agency.

(a) - Documentation for the Human Health Calculated Screening Level for Recreational Use of Surface Water - Wader is provided in Attachment A.
Site-specific risk based screening levels (RBSLs) calculated using USEPA exposure factors and the USEPA screening levels calculator (Hazard Index=1 and Target Risk=1E-05).
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search
(b) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.
(c) - Arsenic RBSLs are based on the lower of the values based on a hazard index of 1 and an excess lifetime cancer risk of 1E-05.
RBSL based on cancer endpoint at 1E-5 (noncancer-based RBSL is 11.1 mg/L).
Of the constituents evaluated, arsenic is the only constituent with an RSL based on potential carcinogenic effects.
(d) - Value for chromium (III) used.
(e) - USEPA lead action level of 0.015 mg/L for lead in drinking water (USEPA, 2018) is used as the RBSL.
(f) - Value for mercuric chloride used.

TABLE 6
ECOLOGICAL SCREENING LEVELS FOR SURFACE WATER - KANSAS RIVER
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

		Ecological Published Screening Levels - Surface Water											
		Kansas Aquatic Life Surface Water Quality Standards (acute) (a) (mg/L)		Kansas Aquatic Life Surface Water Quality Standards (chronic) (a) (mg/L)		USEPA NRWQC Aquatic Life Criteria CMC - Freshwater (acute) (b) (mg/L)		USEPA NRWQC Aquatic Life Criteria CCC - Freshwater (chronic) (b) (mg/L)		Selected Ecological Screening Level (acute) (c) (mg/L)		Selected Ecological Screening Level (chronic) (c) (mg/L)	
Constituent	**CAS RN**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**
Detection Monitoring - USEPA Appendix III Constituents (d)													
Boron	7440-42-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	16984-48-8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Assessment Monitoring - USEPA Appendix IV Constituents													
Antimony	7440-36-0	0.088	NA	0.030	NA	NA	NA	NA	NA	0.088	NA	0.03	NA
Arsenic	7440-38-2	0.34 (h)	NA	0.15 (h)	NA	0.34 (i)	0.34 (i)	0.15 (i)	0.15 (i)	0.34	0.34	0.15	0.15
Barium	7440-39-3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	0.0021 (f)	NA	0.00027 (f)	NA	0.0019 (f)	0.0018 (f)	0.00079 (f)	0.00072 (f)	0.0021	0.0018	0.00027	0.00072
Chromium (Total)	7440-47-3	1.8 (e, f)	NA	0.086 (e, f)	NA	1.8 (e, f)	0.57 (e, f)	0.086 (e, f)	0.074 (e, f)	1.8	0.57	0.086	0.074
Cobalt	7440-48-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	0.082 (f)	NA	0.0032 (f)	NA	0.082 (f)	0.065 (f)	0.0032 (f)	0.0025 (f)	0.082	0.065	0.0032	0.0025
Lithium	7439-93-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.0014	NA	0.00077	NA	0.0016	0.0014	0.00091	0.00077	0.0014	0.0014	0.00077	0.00077
Molybdenum	7439-98-7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	0.02	NA	0.005	NA	NA	NA	NA	0.0031 (g)	0.02	NA	0.005	0.0031
Thallium	7440-28-0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Radiological (pCi/L)													
Radium-226 & 228	7440-14-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

CAS RN - Chemical Abstracts Service Registry Number.
CCC - Continuous Criterion Concentration
CMC - Criterion Maximum Concentration
KDHE - Kansas Department of Health and Environment.
mg/L - milligrams/liter.
NA - Not Available
NRWQC - National Recommended Water Quality Criteria
pCi/L - picoCuries/liter.
USEPA - United States Environmental Protection Agency

Notes:

(a) - Kansas Surface Water Quality Standards. Kansas Department of Health and Environment Bureau of Water. April 11, 2018. Article 16. Kansas Surface Water Quality Standards - Tables of Numeric Criteria

Tables 1a and 1b. Surface Water Quality Standards for metals apply to total recoverable concentrations.
The screening levels for hardness-based metals are calculated for a default hardness value of 100 mg/L $CaCO_3$.
https://kdheks.gov/tmdl/kswqs.htm

(b) - USEPA Water Quality Criteria. Current Water Quality Criteria Tables. National Recommended Water Quality Criteria - Aquatic Life Criteria Table.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm

(c) - The hierarchy for the selection of ecological screening levels is:
1) Kansas Aquatic Life Surface Water Quality Standards.
2) USEPA NRWQC. Aquatic Life Criteria - Freshwater.

(d) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

(e) - Value for chromium (III).

(f) - Criterion expressed as a function of total hardness (mg/L). Value displayed corresponds to a default total hardness of 100 mg/L.

(g) - USEPA Office of Water. Final Criterion: Aquatic Life Ambient Water Quality Criterion for Selenium - Freshwater. 30 June 2016. Freshwater value for chronic (30 day) water column concentration (mg/L) of dissolved selenium in lotic (flowing) surface water. The criterion is based on fish ovary concentrations, and in lieu of that, the water column values are used.
https://www.epa.gov/sites/production/files/2016-07/documents/aquatic_life_awqc_for_selenium_-_freshwater_2016.pdf

(h) - Value for total arsenic.

(i) - Value for inorganic arsenic only.

TABLE 7
SELECTED KANSAS RIVER SURFACE WATER SCREENING LEVELS
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

Constituent	CAS RN	HH DW SL (a) (mg/L)	HH REC SL - Consumption of Organism Only (b) (mg/L)	HH Recreational Calculated RBSL (c) (mg/L)	ECO SL - Total (acute) (d) (mg/L)	ECO SL - Dissolved (acute) (d) (mg/L)	ECO SL - Total (chronic) (d) (mg/L)	ECO SL - Dissolved (chronic) (d) (mg/L)
Detection Monitoring - USEPA Appendix III Constituents (e)								
Boron	7440-42-8	4	NA	114	NA	NA	NA	NA
Fluoride	16984-48-8	2	NA	22.9	NA	NA	NA	NA
Assessment Monitoring - USEPA Appendix IV Constituents								
Antimony	7440-36-0	0.006	0.64	0.171	0.088	NA	0.03	NA
Arsenic	7440-38-2	0.01	0.0014	0.0236	0.34	0.34	0.15	0.15
Barium	7440-39-3	2	NA	63.7	NA	NA	NA	NA
Beryllium	7440-41-7	0.004	NA	0.121	NA	NA	NA	NA
Cadmium	7440-43-9	0.005	0.17	0.134	0.0021	0.0018	0.00027	0.00072
Chromium (Total)	7440-47-3	0.1	3433	155	1.8	0.57	0.086	0.074
Cobalt	7440-48-4	0.006	NA	0.178	NA	NA	NA	NA
Lead	7439-92-1	0.015	NA	0.015	0.082	0.065	0.0032	0.0025
Lithium	7439-93-2	0.04	NA	1.14	NA	NA	NA	NA
Mercury	7439-97-6	0.002	0.000146	0.0956	0.0014	0.0014	0.00077	0.00077
Molybdenum	7439-98-7	0.1	NA	2.86	NA	NA	NA	NA
Selenium	7782-49-2	0.05	4.2	2.86	0.02	NA	0.005	0.0031
Thallium	7440-28-0	0.002	0.0063	0.00572	NA	NA	NA	NA
Radiological (pCi/L)								
Radium-226 & 228	7440-14-4	5	NA	NA	NA	NA	NA	NA

Notes:

CAS RN - Chemical Abstracts Service Registry Number.
ECO SL - Ecological Screening Level.
HH DW SL - Human Health Drinking Water Screening Level.
HH REC SL - Human Health Recreational Use Screening Level.
mg/L - milligrams per liter.
NA - Not Available.
RBSL - Risk-Based Screening Level.

(a) - Drinking Water Screening Levels selected in Table 3 using the following hierarchy:
1) Kansas Domestic Water Supply Surface Water Quality Standards
2) USEPA MCL
3) USEPA RSL - Tap Water

(b) - Human Health Published Screening Values for Surface Water - Consumption of Organism Only selected in Table 3 using the following hierarchy:
1) Kansas Food Procurement Use Surface Water Quality Standards
2) USEPA NRWQC - Consumption of Organism Only.

(c) - The Human Health Calculated Screening Levels are presented in Table 4.
The minimum calculated value for the Off-Site Recreational Wader, Swimmer, and Boater was selected.

(d) - Ecological Screening Levels selected in Table 6 using the following hierarchy:
1) Kansas Aquatic Life Surface Water Quality Standards.
2) USEPA NRWQC. Aquatic Life Criteria - Freshwater.

(e) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

TABLE 8
COMPARISON OF CONSTRUCTION WORKER GROUNDWATER RBSLs TO MAXIMUM GROUNDWATER CONCENTRATIONS - ASH PONDS
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

Constituent	CAS RN	Construction Worker Calculated RBSL - Exposure to Groundwater (a) (mg/L)	Ash Ponds: Maximum Groundwater Concentration - Ash Ponds (b) (mg/L)		Ash Ponds: Is Maximum Groundwater Concentration Above the Construction Worker RBSL?
Detection Monitoring - USEPA Appendix III Constituents (c)					
Boron	7440-42-8	2,100	7.4	MW-40	No
Fluoride	16984-48-8	420	5.5	MW-38	No
Assessment Monitoring - USEPA Appendix IV Constituents					
Antimony	7440-36-0	0.63	<0.0010		No
Arsenic	7440-38-2	3.15	0.076	MW-K	No
Barium	7440-39-3	147	0.094	MW-L	No
Beryllium	7440-41-7	0.368	<0.0010		No
Cadmium	7440-43-9	0.263	<0.00050		No
Chromium (Total)	7440-47-3	205	<0.00050		No
Cobalt	7440-48-4	78.8	0.0028	MW-K	No
Lead	7439-92-1	NA	<0.010		NA
Lithium	7439-93-2	21	0.089	MW-K	No
Mercury	7439-97-6	1.47	<0.00020		No
Molybdenum	7439-98-7	630	0.23	MW-39	No
Selenium	7782-49-2	52.5	<0.0010		No
Thallium	7440-28-0	0.42	<0.0010		No
Radiological (pCi/L)					
Radium-226 & 228	7440-14-4	NA	2.73	MW-K	NA

Notes:
< - Constituent was not detected, value is the reporting limit.
CAS RN - Chemical Abstracts Service Registry Number.
NA - Not Available.
pCi/L - picoCuries/liter.
mg/L - milligrams per liter.
RBSL - Risk-Based Screening Level.
USEPA - United States Environmental Protection Agency.

(a) - Documentation for the Construction Worker Calculated Screening Level for Groundwater is provided in Attachment A.
Site-specific risk based screening levels (RBSLs) calculated using USEPA exposure factors and the USEPA screening levels calculator.
https://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search
(b) - Maximum concentration from downgradient wells.
(c) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

TABLE 9
DERIVATION OF RISK-BASED TARGET SCREENING LEVELS FOR GROUNDWATER - KANSAS RIVER
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

									Dilution Attenuation Factor - Kansas River (e)	1,026	Ash Ponds			
Constituent	CAS RN	HH DW SL (a) (mg/L)	HH REC SL - Consumption of Organism Only (b) (mg/L)	HH Recreational Calculated RBSL (c) (mg/L)	ECO SL - Total (acute) (d) (mg/L)	ECO SL - Dissolved (acute) (d) (mg/L)	ECO SL - Total (chronic) (d) (mg/L)	ECO SL - Dissolved (chronic) (d) (mg/L)	Lowest of the Human Health and Ecological Screening Levels (mg/L)	Target Groundwater Screening Level - Kansas River (f) (mg/L)	Maximum Groundwater Concentration - Ash Ponds (g) (mg/L)		Is Maximum Groundwater Concentration Above the Target Groundwater Screening Level - Kansas River ?	Ratio Between Target Groundwater Screening Level and the Maximum Groundwater Concentration (h)
Detection Monitoring - USEPA Appendix III Constituents (i)														
Boron	7440-42-8	4	NA	114	NA	NA	NA	NA	4	4,104	7.4	MW-40	No	>550
Fluoride	16984-48-8	2	NA	22.9	NA	NA	NA	NA	2	2,052	5.5	MW-38	No	>370
Assessment Monitoring - USEPA Appendix IV Constituents														
Antimony	7440-36-0	0.006	0.64	0.171	0.088	NA	0.03	NA	0.006	6	<0.0010		ND	ND
Arsenic	7440-38-2	0.01	0.0014	0.0236	0.34	0.34	0.15	0.15	0.0014	1.44	0.076	MW-K	No	>18
Barium	7440-39-3	2	NA	63.7	NA	NA	NA	NA	2	2,052	0.094	MW-L	No	>21,000
Beryllium	7440-41-7	0.004	NA	0.121	NA	NA	NA	NA	0.004	4.10	<0.0010		ND	ND
Cadmium	7440-43-9	0.005	0.17	0.134	0.0021	0.0018	0.00027	0.00072	0.00027	0.28	<0.00050		ND	ND
Chromium (Total)	7440-47-3	0.1	3,433	155	1.8	0.57	0.086	0.074	0.074	76	<0.00050		ND	ND
Cobalt	7440-48-4	0.006	NA	0.178	NA	NA	NA	NA	0.006	6.2	0.0028	MW-K	No	>2,100
Lead	7439-92-1	0.015	NA	0.015	0.082	0.065	0.0032	0.0025	0.0025	2.6	<0.010		ND	ND
Lithium	7439-93-2	0.04	NA	1.14	NA	NA	NA	NA	0.04	41	0.089	MW-K	No	>460
Mercury	7439-97-6	0.002	0.000146	0.0956	0.0014	0.0014	0.00077	0.00077	0.000146	0.150	<0.00020		ND	ND
Molybdenum	7439-98-7	0.1	NA	2.86	NA	NA	NA	NA	0.1	103	0.23	MW-39	No	>440
Selenium	7782-49-2	0.05	4.2	2.86	0.02	NA	0.005	0.0031	0.0031	3	<0.0010		ND	ND
Thallium	7440-28-0	0.002	0.0063	0.00572	NA	NA	NA	NA	0.002	2.05	<0.0010		ND	ND
Radiological (pCi/L)														
Radium-226 & 228	7440-14-4	5	NA	NA	NA	NA	NA	NA	5	5,130	2.73	MW-K	No	>1,800

Notes:

< - Constituent was not detected, value is the reporting limit.
CAS RN - Chemical Abstracts Service Registry Number.
ECO SL - Ecological Screening Level.
HH DW SL - Human Health Drinking Water Screening Level.
HH REC SL - Human Health Recreational Use Screening Level.
mg/L - milligrams per liter.
NA - Not Available.
ND - Not detected.
RBSL - Risk-Based Screening Level.

TABLE 9
DERIVATION OF RISK-BASED TARGET SCREENING LEVELS FOR GROUNDWATER - KANSAS RIVER
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

(a) - Drinking Water Screening Levels selected in Table 3 using the following hierarchy:
  1) Kansas Domestic Water Supply Surface Water Quality Standards
  2) USEPA MCL
  3) USEPA RSL - Tap Water

(b) - Human Health Published Screening Values for Surface Water - Consumption of Organism Only selected in Table 3 using the following hierarchy:
  1) Kansas Food Procurement Use Surface Water Quality Standards
  2) USEPA NRWQC - Consumption of Organism Only.

(c) - The Human Health Calculated Screening Levels are presented in Table 4.
The minimum calculated value for the Off-Site Recreational Wader, Swimmer, and Boater was selected.

(d) - Ecological Screening Levels selected in Table 6 using the following hierarchy:
  1) Kansas Aquatic Life Surface Water Quality Standards.
  2) USEPA NRWQC. Aquatic Life Criteria - Freshwater.

(e) - Estimated value, see Attachment B for derivation.

(f) - The Target Groundwater Screening Level = Minimum SL x Dilution Factor.

(g) - Maximum concentration from downgradient wells.

(h) - Ratio = Target Groundwater Screening Level / Maximum Groundwater Concentration.

(i) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

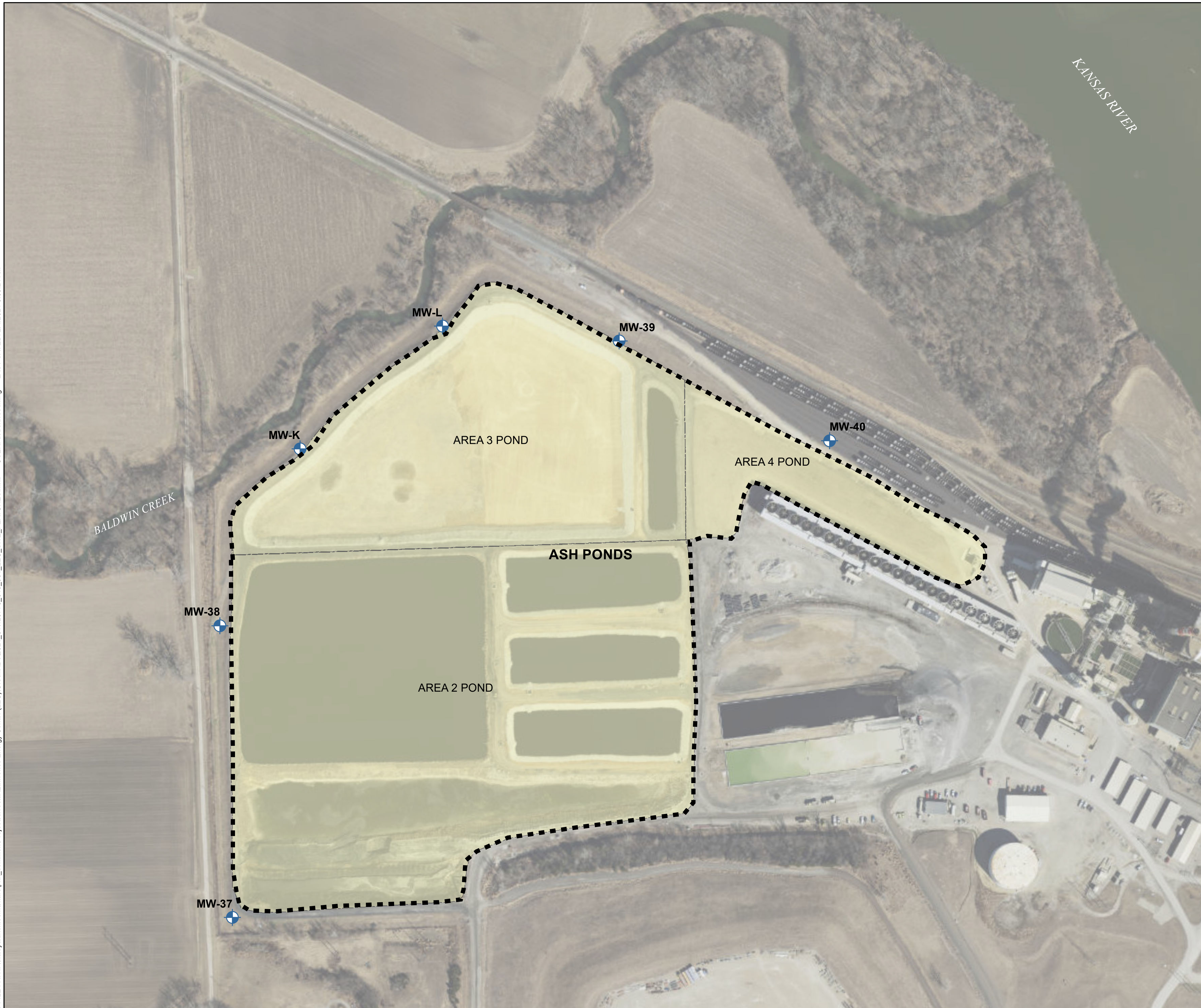
TABLE 10
COMPARISON OF RECREATIONAL WADER BALDWIN CREEK SURFACE WATER RBSLs TO MAXIMUM GROUNDWATER CONCENTRATIONS - ASH POND
LAWRENCE ENERGY CENTER - ASH PONDS
LAWRENCE, KANSAS

Constituent	CAS RN	Current/Future Off-Site Recreational Wader RBSLs - Exposure to Baldwin Creek Surface Water (a) (mg/L)	Ash Ponds: Maximum Groundwater Concentration - Ash Ponds (b) (mg/L)		Ash Ponds: Is Maximum Groundwater Concentration Above the Recreational Wader RBSL?
Detection Monitoring - USEPA Appendix III Constituents (c)					
Boron	7440-42-8	1,030	7.4	MW-40	No
Fluoride	16984-48-8	207	5.5	MW-38	No
Assessment Monitoring - USEPA Appendix IV Constituents					
Antimony	7440-36-0	1.12	<0.0010		No
Arsenic	7440-38-2	0.274	0.076	MW-K	No
Barium	7440-39-3	345	0.094	MW-L	No
Beryllium	7440-41-7	0.463	<0.0010		No
Cadmium	7440-43-9	0.67	<0.00050		No
Chromium (Total)	7440-47-3	624	<0.00050		No
Cobalt	7440-48-4	1.7	0.0028	MW-K	No
Lead	7439-92-1	0.015	<0.010		No
Lithium	7439-93-2	10.3	0.089	MW-K	No
Mercury	7439-97-6	0.517	<0.00020		No
Molybdenum	7439-98-7	25.8	0.23	MW-39	No
Selenium	7782-49-2	25.8	<0.0010		No
Thallium	7440-28-0	0.0517	<0.0010		No
Radiological (pCi/L)					
Radium-226 & 228	7440-14-4	NA	2.73	MW-K	NA

Notes:
< - Constituent was not detected, value is the reporting limit.
CAS RN - Chemical Abstracts Service Registry Number.
NA - Not Available.
pCi/L - picoCuries/liter.
mg/L - milligrams per liter.
RBSL - Risk-Based Screening Level.
USEPA - United States Environmental Protection Agency.

(a) - The Baldwin Creek Recreational Wader RBSLs are presented in Table 5.
(b) - Maximum concentration from downgradient wells.
(c) - Detection Monitoring - EPA Appendix III Constituents without health risk-based screening levels are not included.

FIGURES



LEGEND

MONITORING WELL

LIMITS OF FORMER ASH PONDS

NOTE: ASH POND REMOVAL COMPLETED IN 2018. REMOVAL OF REMAINING ASH POND BERMS TO BE COMPLETED IN 2021

NOTES

1. ALL LOCATIONS, BOUNDARIES, AND DIMENSIONS ARE APPROXIMATE.

2. AERIAL IMAGERY SOURCE: ESRI, 17 APRIL 2018

HALEY ALDRICH

EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

SITE FEATURES

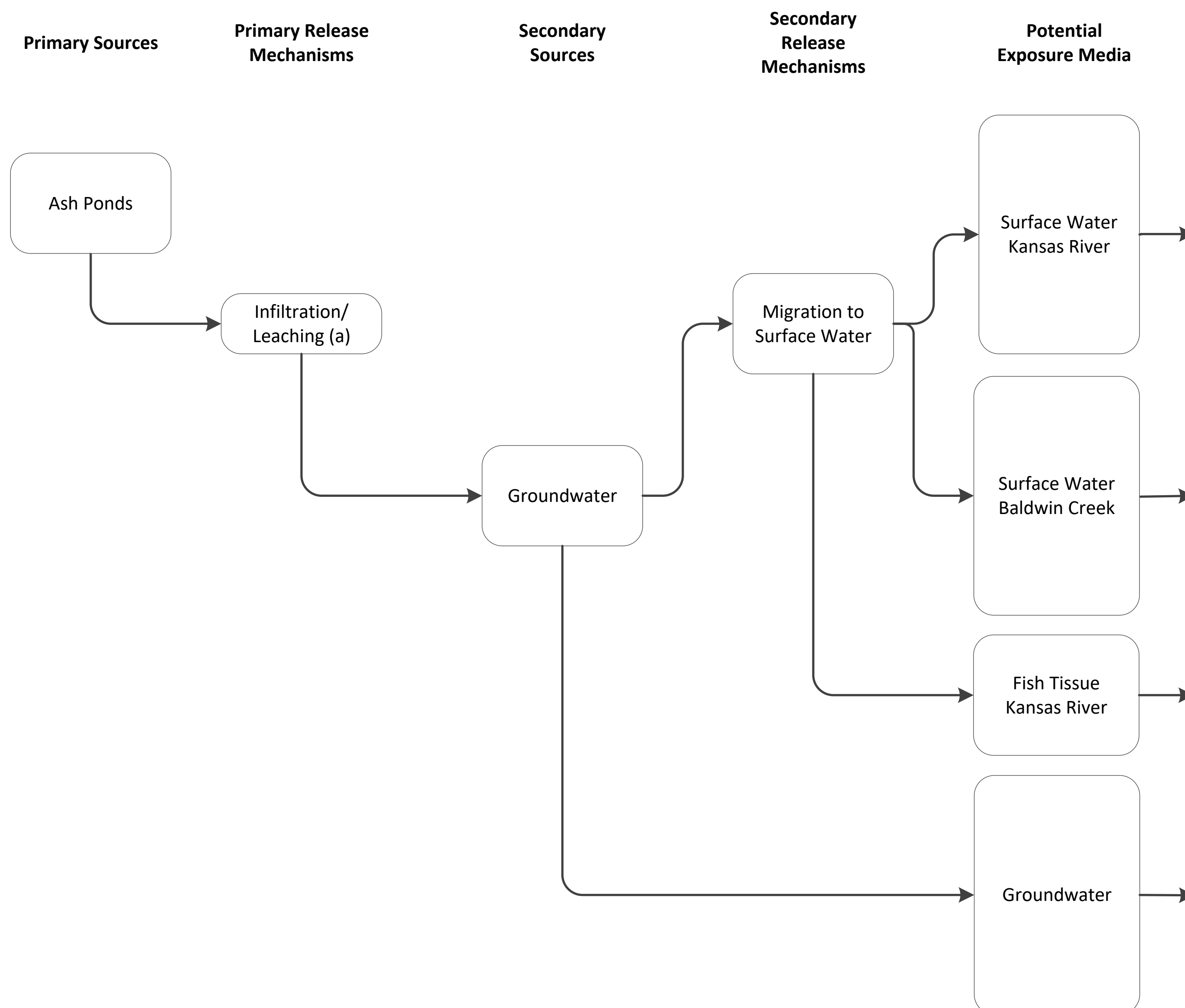
evergy

FEBRUARY 2021

FIGURE 1

GIS FILE PATH: \\haleyaldrich.com\share\phx_common\Projects\Westar\Lawrence Energy Center (LEC)\GIS\MXDs\2021_01\129778_043_001_LEC_SITE_FEATURES.mxd — USER: doberbroeckling — LAST SAVED: 2/4/2021 8:05:24 AM

FIGURE 2
CONCEPTUAL SITE MODEL
EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER – ASH PONDS
LAWRENCE, KANSAS



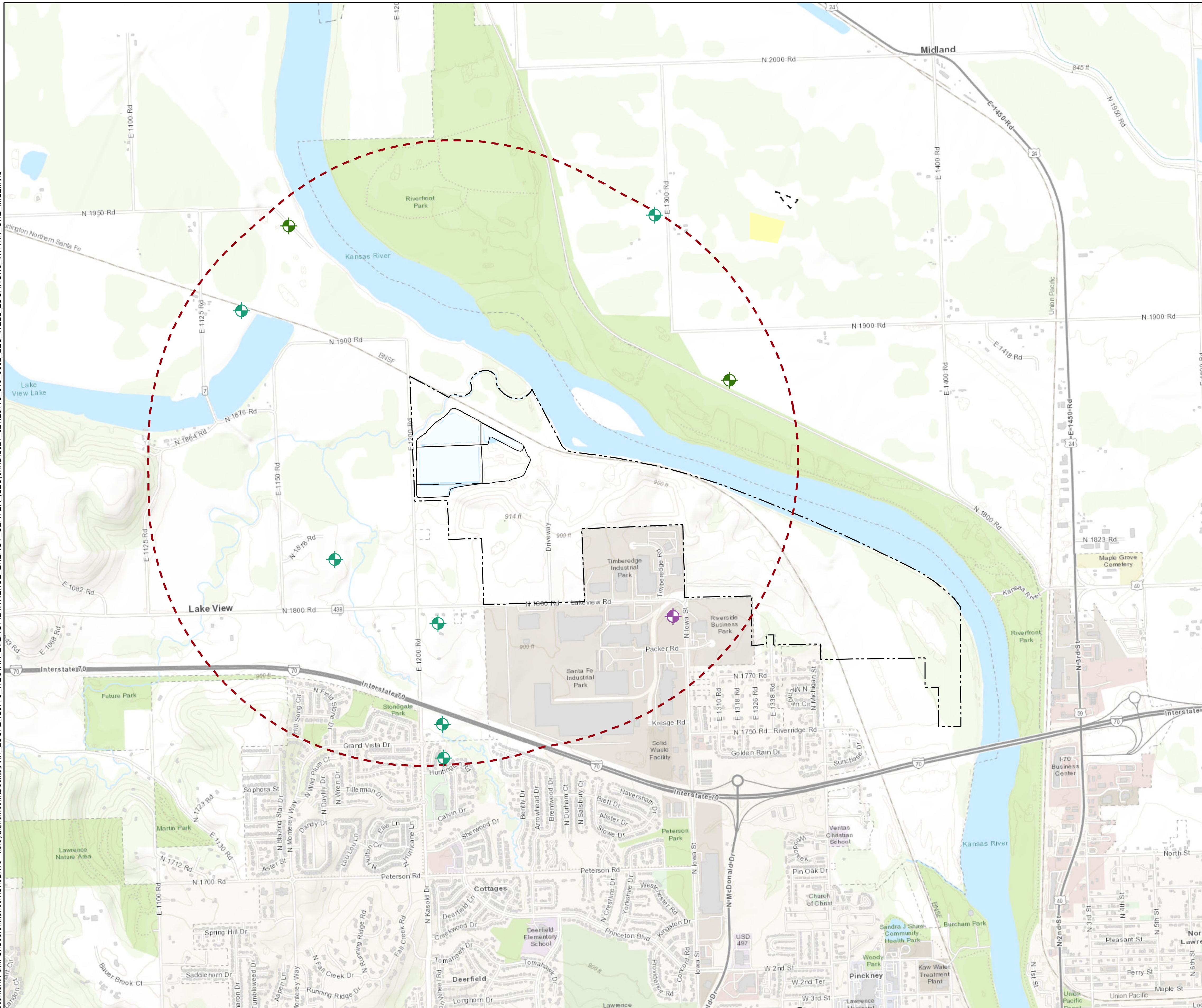
	Potential Human Health Receptors					Potential Ecological Receptors
Potential Exposure Route	Current/Future Off-Site Resident Adult/Child	Current/Future Off-Site Recreational Swimmer/Boater	Current/Future Off-Site Recreational Wader	Current/Future Off-Site Recreational Fisher	Current/Future Construction Worker	Aquatic Receptors
Drinking Water Use	⊙ (b)	O	O	O	O	NA
Incidental Ingestion	O	⊙	⊙	⊙	⊙	NA
Dermal Contact	O	⊙	⊙	⊙	⊙	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Drinking Water Use	O (c)	O	O	O	O	NA
Incidental Ingestion	O	O (d)	⊙	O (d)	O (d)	NA
Dermal Contact	O	O (d)	⊙	O (d)	O (d)	NA
Aquatic Exposure	NA	NA	NA	NA	NA	O (d)
Ingestion	O	O	O	⊙	⊙	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Drinking Water Use	O (e)	O	O	O	O	NA
Incidental Ingestion	O	O	O	O	O	NA
Dermal Contact	O	O	O	O	⊙	NA
Aquatic Exposure	NA	NA	NA	NA	NA	O (f)

Notes:

- ● Pathway potentially complete
- ⊙ Pathway potentially complete – pathway evaluated in this risk assessment; results indicate no risk to human health or the environment.
- O Pathway evaluated and found incomplete; results indicate no risk to human health or the environment.

(a) Flooding/runoff from the ponds is not a primary release mechanism, pond runoff is through the outfall stream.
(b) The Kansas River is used as a source of drinking water; the nearest downstream drinking water intake is 3 miles downstream at the City of Lawrence, Kansas.
(c) Baldwin Creek is not used as a source of drinking water.
(d) The size of Baldwin Creek precludes swimming, fishing and boating activities. The periodic drying of the Creek precludes consumptive fisheries and aquatic habitats in the Creek.
(e) The shallow alluvial aquifer in the vicinity of the Ash Ponds is not used for drinking water purposes.
(f) Ecological Receptors are not exposed to groundwater.

NA – Not Applicable.



LEGEND

- DOMESTIC WELL
- IRRIGATION WELL
- MONITORING WELL/PIEZOMETER/OBSERVATION (NON-EVERGY)
- ASH POND BOUNDARY
- LEC BOUNDARY
- ONE-MILE SEARCH RADIUS

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.

2. WELL DATA SOURCE: KANSAS GEOLOGICAL SURVEY, WATER WELL COMPLETION RECORDS (WWC5)DATABASE, INTERACTIVE MAP OF WWC5 DATA, 15 DECEMBER 2020.

3. IMAGERY SOURCE: ESRI

N

0 2,000 4,000

SCALE IN FEET

HALEY ALDRICH

EVERGY KANSAS CENTRAL, INC.
LAWRENCE ENERGY CENTER
LAWRENCE, KANSAS

WELL LOCATIONS WITHIN A ONE-MILE RADIUS OF ASH PONDS

evergy

FEBRUARY 2021

FIGURE 3

ATTACHMENT A

Calculated Recreational and Construction Worker Risk-Based Screening Levels

Current/Future Construction Worker

TABLE A-1
HUMAN HEALTH EXPOSURE PARAMETERS FOR DERIVATION OF RISK BASED SCREENING LEVELS (RBSLs) - CONSTRUCTION WORKER

Exposure Parameter			Units	Current/Future Construction Worker	
Standard Parameters					
	Body Weight	BW	kg	80	USEPA, 2014
	Exposure Duration	ED	years	1	Site-specific [2]
	Non–carcinogenic Averaging Time	Atnc	days	365	ED expressed in days
	Carcinogenic Averaging Time	Atc	days	25550	70 year lifetime
Incidental Ingestion of Groundwater					
	Exposure Frequency	EF	days/year	NA	
	Water Ingestion Rate	IR	L/day	NA	
	Fraction Ingested	FI	unitless	NA	
Dermal Exposure with Groundwater					
	Exposure Frequency	EF	days/year	60	Site-specific [2]
	Exposed Skin Surface Area	SA	cm^2	5790	USEPA, 2011 [1]
	Exposure Time	t-event	hr/event	8	Site-specific [2]
	Events per Day	EV	event/day	1	Site-specific [2]

NOTES AND ABBREVIATIONS

USEPA, 2011 - Exposure Factors Handbook. USEPA/600/R-10/030. October, 2011.
USEPA, 2014 - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6, 201.
[1] - Based on surface area of hands, forearms, lower legs, and feet.
[2] - Assumes 8 hours per event and that on days when exposure to groundwater occurs, all daily exposure is derived from locations at the Site.
For this scenario, an exposure frequency of 60 days per year was used, assuming excavation activities over a total of 12 weeks in a project that would take up to a year to complete.

Site-specific

Recreator Equation Inputs for Surface Water

* Inputted values different from Recreator defaults are highlighted.

Variable	Recreator Surface Water Default Value	Form-input Value
BW_{0-2} (body weight) kg	15	0
BW_{2-6} (body weight) kg	15	0
BW_{6-16} (body weight) kg	80	0
BW_{16-30} (body weight) kg	80	80
BW_{a} (body weight - adult) kg	80	80
BW_{rec-a} (body weight - adult) kg	80	80
$DFW_{rec-adj}$ (age-adjusted dermal factor) cm^2-event/kg	0	4342.5
$DFWM_{rec-adj}$ (mutagenic age-adjusted dermal factor) cm^2-event/kg	0	4342.5
ED_{rec} (exposure duration - recreator) years	26	1
ED_{0-2} (exposure duration) years	2	0
ED_{2-6} (exposure duration) years	4	0
ED_{6-16} (exposure duration) years	10	0
ED_{16-30} (exposure duration) years	10	1
ED_{rec-a} (exposure duration - adult) years	20	1
EF_{rec-w} (exposure frequency) days/year	0	60
EF_{2-6} (exposure frequency) days/year	0	0
EF_{6-16} (exposure frequency) days/year	0	0
EF_{16-30} (exposure frequency) days/year	0	60
EF_{rec-a} (adult exposure frequency) days/year	0	60
ET_{0-2} (exposure time) hours/event	0	0
ET_{2-6} (exposure time) hours/event	0	0
ET_{6-16} (exposure time) hours/event	0	0
ET_{16-30} (exposure time) hours/event	0	8
ET_{rec-a} (adult exposure time) hours/event	0	8
EV_{0-2} (events) events/day	0	0
EV_{2-6} (events) events/day	0	0
EV_{6-16} (events) events/day	0	0
EV_{16-30} (events) events/day	0	1
EV_{rec-a} (adult) events/day	0	1
THQ (target hazard quotient) unitless	0.1	1
$IFW_{rec-adj}$ (age-adjusted water intake rate) L/kg	0	0
$IFWM_{rec-adj}$ (mutagenic age-adjusted water intake rate) L/kg	0	0
IRW_{0-2} (water intake rate) L/hour	0.12	0
IRW_{2-6} (water intake rate) L/hour	0.12	0
IRW_{6-16} (water intake rate) L/hour	0.124	0
IRW_{16-30} (water intake rate) L/hour	0.0985	0
IRW_{rec} (water intake rate - adult) L/day	0.11	0
IRW_{rec-a} (water intake rate - adult) L/hr	0.11	0
LT (lifetime - recreator) years	70	70
SA_{0-2} (skin surface area) cm^2	6365	0
SA_{2-6} (skin surface area) cm^2	6365	0
SA_{6-16} (skin surface area) cm^2	19652	0
SA_{16-30} (skin surface area) cm^2	19652	5790
SA_{rec} (skin surface area - adult) cm^2	19652	5790
SA_{rec-a} (skin surface area - adult) cm^2	19652	5790
Apparent thickness of stratum corneum (cm)	0.001	0.001
TR (target risk) unitless	0.000001	0.00001

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Site-specific

Recreator Regional Screening Levels (RSL) for Surface Water

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o(mg/kg-day)$^{-1}$	SF_oRef	RfD (mg/kg-day)	RfD Ref	RfC (mg/m^3)	RfC Ref	RAGSe GIABS (unitless)	K_p (cm/hr)	MW	FA (unitless)	In EPD?	$DA_{event(ca)}$	$DA_{event(ncchild)}$	$DA_{event(nc\ adult)}$	Ingestion SL TR=1E-05 (ug/L)	Dermal SL TR=1E-05 (ug/L)	Carcinogenic SL TR=1E-05 (ug/L)	Ingestion SL (Child) THQ=1 (ug/L)	Dermal SL (Child) THQ=1 (ug/L)	Noncarcinogenic SL (Child) THQ=1 (ug/L)	Ingestion SL (Adult) THQ=1 (ug/L)	Dermal SL (Adult) THQ=1 (ug/L)	Noncarcinogenic SL (Adult) THQ=1 (ug/L)	Screening Level (ug/L)
Antimony (metallic)	7440-36-0	No	No	Inorganics	-		0.0004	/Subchronic	0.0010	A /Subchronic	0.1500	0.0010	121.7600	1.0000	Yes	-	-	0.0050	-	-	-	-	-	-	-	630.0000	630.0000	6.30E+02nc
Arsenic, Inorganic	7440-38-2	No	No	Inorganics	1.5000	I	0.0003	I /Chronic	0.0000	C /Chronic	1.0000	0.0010	74.9220	1.0000	Yes	0.0392	-	0.0252	-	4900.0000	4900.0000	-	-	-	-	3150.0000	3150.0000	3.15E+03nc
Barium	7440-39-3	No	No	Inorganics	-		0.2000	/Subchronic	0.0050	H /Subchronic	0.0700	0.0010	137.3300	1.0000	Yes	-	-	1.1767	-	-	-	-	-	-	-	147000.0000	147000.0000	1.47E+05nc
Beryllium and compounds	7440-41-7	No	No	Inorganics	-		0.0050	/Subchronic	0.0000	I /Chronic	0.0070	0.0010	9.0100	1.0000	Yes	-	-	0.0029	-	-	-	-	-	-	-	368.0000	368.0000	3.68E+02nc
Boron And Borates Only	7440-42-8	No	No	Inorganics	-		0.2000	/Subchronic	0.0200	H /Subchronic	1.0000	0.0010	13.8400	1.0000	Yes	-	-	16.8106	-	-	-	-	-	-	-	2100000.0000	2100000.0000	2.10E+06nc
Cadmium (Water)	7440-43-9	No	No	Inorganics	-		0.0005	/Subchronic	0.0000	A /Chronic	0.0500	0.0010	112.4000	1.0000	Yes	-	-	0.0021	-	-	-	-	-	-	-	263.0000	263.0000	2.63E+02nc
Chromium(III), Insoluble Salts	16065-83-1	No	No	Inorganics	-		1.5000	/Subchronic	0.0050	A /Subchronic	0.0130	0.0010	52.0000	1.0000	Yes	-	-	1.6390	-	-	-	-	-	-	-	205000.0000	205000.0000	2.05E+05nc
Cobalt	7440-48-4	No	No	Inorganics	-		0.0030	/Subchronic	0.0000	P /Subchronic	1.0000	0.0004	58.9300	1.0000	Yes	-	-	0.2522	-	-	-	-	-	-	-	78800.0000	78800.0000	7.88E+04nc
Fluoride	16984-48-8	No	No	Inorganics	-		0.0400	C /Chronic	0.0130	C /Chronic	1.0000	0.0010	38.0000	1.0000	Yes	-	-	3.3621	-	-	-	-	-	-	-	420000.0000	420000.0000	4.20E+05nc
Lithium	7439-93-2	No	No	Inorganics	-		0.0020	/Subchronic	-		1.0000	0.0010	6.9400	1.0000	Yes	-	-	0.1681	-	-	-	-	-	-	-	21000.0000	21000.0000	2.10E+04nc
Mercuric Chloride	7487-94-7	No	No	Inorganics	-		0.0020	/Subchronic	0.0003	G /Chronic	0.0700	0.0010	271.5000	1.0000	Yes	-	-	0.0118	-	-	-	-	-	-	-	1470.0000	1470.0000	1.47E+03nc
Molybdenum	7439-98-7	No	No	Inorganics	-		0.0600	/Subchronic	0.0020	A /Chronic	1.0000	0.0010	95.9400	1.0000	Yes	-	-	5.0432	-	-	-	-	-	-	-	630000.0000	630000.0000	6.30E+05nc
Selenium	7782-49-2	No	No	Inorganics	-		0.0050	/Subchronic	0.0200	C /Chronic	1.0000	0.0010	78.9600	1.0000	Yes	-	-	0.4203	-	-	-	-	-	-	-	52500.0000	52500.0000	5.25E+04nc
Thallium (Soluble Salts)	7440-28-0	No	No	Inorganics	-		0.0000	/Subchronic	-		1.0000	0.0010	204.3800	1.0000	Yes	-	-	0.0034	-	-	-	-	-	-	-	420.0000	420.0000	4.20E+02nc

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Current/Future Off-Site Recreational Wader – Baldwin Creek

TABLE A-2
HUMAN HEALTH EXPOSURE PARAMETERS FOR DERIVATION OF RISK BASED SCREENING LEVELS (RBSLs) - RECREATIONAL WADER - BALDWIN CREEK

Exposure Parameter		Units	Current/Future Off-Site Recreational Wader							
			Child (Age <6)		Adolescent (6-<16 years)		Adult		Child, Adolescent and Adult (Ages 1 - 26)	
Standard Parameters										
Body Weight	BW	kg	15	USEPA, 2011 [1]	44	USEPA, 2011 [1]	80	USEPA, 2014a	NA	
Exposure Duration	ED	years	6	Ages <6	10	Ages 6 - <16	10	Balance of 26-yr exposure	26	
Non–carcinogenic Averaging Time	Atnc	days	2190	ED expressed in days	3650	ED expressed in days	3650	ED expressed in days	9490	ED expressed in days
Carcinogenic Averaging Time	Atc	days	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime	25550	70 year lifetime
Incidental Ingestion of Surface Water										
Exposure Frequency	EF	days/year	45	USEPA, 2014b	45	USEPA, 2014b	45	USEPA, 2014b	45	USEPA, 2014b
Water Ingestion Rate	IR	L/day	0.01	USEPA, 2014b [2]	0.002	USEPA, 2014b [2]	0.002	USEPA, 2014b [2]	NA	
Fraction Ingested	FI	unitless	1.0	Assumption	1.0	Assumption	1.0	Assumption	1.0	Assumption
Age-Adjusted Water Ingestion Factor	IFWadj	L/kg	NA		NA		NA		0.21	
Age-Adjusted Water Ingestion Factor-Mutagenic	IFWM	L/kg	NA		NA		NA		1.03	
Dermal Exposure with Surface Water										
Exposure Frequency	EF	days/year	45	USEPA, 2014b	45	USEPA, 2014b	45	USEPA, 2014b	45	USEPA, 2014b
Exposed Skin Surface Area	SA	cm^2	1770	USEPA, 2011 [3]	3820	USEPA, 2011 [3]	5790	USEPA, 2011 [3]	NA	
Exposure Time	t-event	hr/event	2	Site-specific [4]	2	Site-specific [4]	2	Site-specific [4]	2	Site-specific
Events per Day	EV	event/day	1.0	Site-specific [4]	1.0	Site-specific [4]	1.0	Site-specific [4]	1.0	Site-specific
Age-Adjusted Dermal Contact Factor	DFWadj	events-cm^2/kg	NA		NA		NA		103497	
Age-Adjusted Dermal Contact Factor-Mutagenic	DFWM	events-cm^2/kg	NA		NA		NA		319693	

NOTES AND ABBREVIATIONS

USEPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OWSWER 9355.4-24
USEPA, 2011 - Exposure Factors Handbook. USEPA/600/R-10/030. October, 2011.
USEPA, 2014a - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6, 2014.
USEPA, 2014b - Region 4 Human Health Risk Assessment Supplemental Guidance. January 2014. Draft Final.
[1] - Table 8-1 of USEPA (2011).
[2] - Ingestion rates for exposure to surface water during wading adjusted to 5 ml/hour for children 1-6, and 1 ml/hour for adolescents and adults due to the shallow depth of Baldwin Creek.
The water ingestion rate in liters/day is calculated as follows: ingestion (ml/hr) x exposure time (hr/event)/1000 (ml/L).
[3] - Based on surface area of hands, forearms, lower legs, and feet.
[4] - Assumes 2 hours per event and that on days when recreation in water occurs, all daily exposure to water is derived from locations at the Site.

Values based on a time-weighted average of child, adolescent, and adult exposure values are calculated as follows:
Water
IFWadj = (child ED [0-2] x child EF [0-2] x child IR [0-2] / child BW [0-2]) + (child ED [2-6] x child EF [2-6] x child IR [2-6] / child BW [2-6]) + (older child ED [6-16] x older child EF [6-16] x older child IR [6-16] / older child BW [6-16]) + (adult ED x adult EF x adult IR / adult BW)
DFWadj = (child EF [0-2] x child ED [0-2] x child SA [0-2] x child EV [0-2] / child BW [0-2]) + (child EF [2-6] x child ED [2-6] x child SA [2-6] x child EV [2-6] / child BW [2-6]) + (older child EF [6-16] x older child ED [6-16] x older child SA [6-16] x older child EV [6-16] / older child BW [6-16]) + (adult EF x adult ED x adult SA x adult EV / adult BW)
Water - mutagenic
IFWM = (child ED [0-2] x child EF [0-2] x child IR [0-2] x ADAF [0-2] / child BW [0-2]) + (child ED [2-6] x child EF [2-6] x child IR [2-6] x ADAF [2-6] / child BW [2-6]) + (older child ED [6-16] x child EF [6-16] x older child IR [6-16] x ADAF [6-16] / older child BW [6-16]) + (adult ED x adult EF x adult IR x adult ADAF / adult BW)
DFWM = (child EF [0-2] x child ED [0-2] x child SA [0-2] x child EV [0-2] x ADAF [0-2] / child BW [0-2]) + (child EF [2-6] x child ED [2-6] x child SA [2-6] x child EV [2-6] x ADAF [2-6] / child BW [2-6]) + (older child EF [6-16] x older child ED [6-16] x older child SA [6-16] x older child EV [6-16] x ADAF [6-16] / older child BW [6-16]) + (adult EF x adult ED x adult SA x adult EV x adult ADAF / adult BW)

USEPA guidance for early life exposure to carcinogens (USEPA, 2005) requires that risks for potentially carcinogenic constituents that are presumed to act by a mutagenic mode of action be calculated differently than for constituents that do not act via a mutagenic mode of action.
Therefore, the age-dependent adjustment factors (ADAF) will be applied for calculations involving children under the age of 16. The ADAFs are as follows:
Age 0 to 2 years (2 year interval from birth until 2nd birthday) – ADAF = 10
Ages 2 to 16 years (14 year interval from 2nd birthday to 16th birthday) – ADAF = 3
Ages 16 and up (after 16th birthday) – no adjustment - ADAF = 1
The exposure parameters for children ages <6 are applied to children 0 - 2 and 2- 6.

Site-specific

Recreator Equation Inputs for Surface Water

* Inputted values different from Recreator defaults are highlighted.

Variable	Recreator Surface Water Default Value	Form-input Value
BW_{0-2} (body weight) kg	15	15
BW_{2-6} (body weight) kg	15	15
BW_{6-16} (body weight) kg	80	44
BW_{16-30} (body weight) kg	80	80
BW_{a} (body weight - adult) kg	80	62
BW_{rec-a} (body weight - adult) kg	80	62
$DFW_{rec-adj}$ (age-adjusted dermal factor) cm^2-event/kg	0	101610
$DFWM_{rec-adj}$ (mutagenic age-adjusted dermal factor) cm^2-event/kg	0	319693.295
ED_{rec} (exposure duration - recreator) year	26	26
ED_{0-2} (exposure duration) years	2	2
ED_{2-6} (exposure duration) years	4	4
ED_{6-16} (exposure duration) years	10	10
ED_{16-30} (exposure duration) years	10	10
ED_{rec-a} (exposure duration - adult) year	20	20
EF_{rec-w} (exposure frequency) days/year	0	45
EF_{2-6} (exposure frequency) days/year	0	45
EF_{6-16} (exposure frequency) days/year	0	45
EF_{16-30} (exposure frequency) days/year	0	45
EF_{rec-a} (adult exposure frequency) days/year	0	45
ET_{0-2} (exposure time) hours/event	0	2
ET_{2-6} (exposure time) hours/event	0	2
ET_{6-16} (exposure time) hours/event	0	2
ET_{16-30} (exposure time) hours/event	0	2
ET_{rec-a} (adult exposure time) hours/event	0	2
EV_{0-2} (events) events/day	0	1
EV_{2-6} (events) events/day	0	1
EV_{6-16} (events) events/day	0	1
EV_{16-30} (events) events/day	0	1
EV_{rec-a} (adult) events/day	0	1
THQ (target hazard quotient) unitless	0.1	1
$IFW_{rec-adj}$ (age-adjusted water intake rate) L/kg	0	0.418
$IFWM_{rec-adj}$ (mutagenic age-adjusted water intake rate) L/kg	0	2.065
IRW_{0-2} (water intake rate) L/hour	0.12	0.01
IRW_{2-6} (water intake rate) L/hour	0.12	0.01
IRW_{6-16} (water intake rate) L/hour	0.124	0.002
IRW_{16-30} (water intake rate) L/hour	0.0985	0.002
IRW_{rec} (water intake rate - adult) L/day	0.11	0.002
IRW_{rec-a} (water intake rate - adult) L/h	0.11	0.002
LT (lifetime - recreator) years	70	70
SA_{0-2} (skin surface area) cm^2	6365	1770
SA_{2-6} (skin surface area) cm^2	6365	1770
SA_{6-16} (skin surface area) cm^2	19652	3820
SA_{16-30} (skin surface area) cm^2	19652	5790
SA_{rec} (skin surface area - adult) cm^2	19652	4805
SA_{rec-a} (skin surface area - adult) cm^2	19652	4805
Apparent thickness of stratum corneum (cm)	0.001	0.001
TR (target risk) unitless	0.000001	0.00001

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Site-specific

Recreator Regional Screening Levels (RSL) for Surface Water

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o(mg/kg-day)$^{-1}$	SF_o Ref	RfD (mg/kg-day)	RfD Ref	RfC (mg/m^3)	RfC Ref	RAGSe GIABS (unitless)	K_p (cm/hr)	MW	FA (unitless)	In EPD?	$DA_{event(ca)}$	$DA_{event(nc\ child)}$	$DA_{event(nc\ adult)}$	Ingestion SL TR=1E-05 (ug/L)	Dermal SL TR=1E-05 (ug/L)	Carcinogenic SL TR=1E-05 (ug/L)	Ingestion SL (Child) THQ=1 (ug/L)	Dermal SL (Child) THQ=1 (ug/L)	Noncarcinogenic SL (Child) THQ=1 (ug/L)	Ingestion SL (Adult) THQ=1 (ug/L)	Dermal SL (Adult) THQ=1 (ug/L)	Noncarcinogenic SL (Adult) THQ=1 (ug/L)	Screening Level (ug/L)
Antimony (metallic)	7440-36-0	No	No	Inorganics	-		0.0004	I	0.0003	A	0.1500	0.0010	121.7600	1.0000	Yes	-	0.0041	0.0063	-	-	-	2430.0000	2060.0000	1120.0000	50300.0000	3140.0000	2960.0000	1.12E+03nc
Arsenic, Inorganic	7440-38-2	No	No	Inorganics	1.5000	I	0.0003	I	0.0000	C	1.0000	0.0010	74.9220	1.0000	Yes	0.0017	0.0206	0.0314	407.0000	838.0000	274.0000	1830.0000	10300.0000	1550.0000	37700.0000	15700.0000	11100.0000	2.74E+02ca**
Barium	7440-39-3	No	No	Inorganics	-		0.2000	I	0.0005	H	0.0700	0.0010	137.3300	1.0000	Yes	-	0.9623	1.4652	-	-	-	1220000.0000	481000.0000	345000.0000	25100000.0000	733000.0000	712000.0000	3.45E+05nc
Beryllium and compounds	7440-41-7	No	No	Inorganics	-		0.0020	I	0.0000	I	0.0070	0.0010	9.0100	1.0000	Yes	-	0.0010	0.0015	-	-	-	12200.0000	481.0000	463.0000	251000.0000	733.0000	730.0000	4.63E+02nc
Boron And Borates Only	7440-42-8	No	No	Inorganics	-		0.2000	I	0.0200	H	1.0000	0.0010	13.8400	1.0000	Yes	-	13.7476	20.9319	-	-	-	1220000.0000	6870000.0000	1030000.0000	25100000.0000	10500000.0000	7390000.0000	1.03E+06nc
Cadmium (Water)	7440-43-9	No	No	Inorganics	-		0.0005	I	0.0000	A	0.0500	0.0010	112.4000	1.0000	Yes	-	0.0017	0.0026	-	-	-	3040.0000	859.0000	670.0000	62900.0000	1310.0000	1280.0000	6.70E+02nc
Chromium(III), Insoluble Salts	16065-83-1	No	No	Inorganics	-		1.5000	I	-		0.0130	0.0010	52.0000	1.0000	Yes	-	1.3404	2.0409	-	-	-	9130000.0000	670000.0000	624000.0000	189000000.0000	1020000.0000	1010000.0000	6.24E+05nc
Cobalt	7440-48-4	No	No	Inorganics	-		0.0003	P	0.0000	P	1.0000	0.0004	58.9300	1.0000	Yes	-	0.0206	0.0314	-	-	-	1830.0000	25800.0000	1700.0000	37700.0000	39200.0000	19200.0000	1.70E+03nc
Fluoride	16984-48-8	No	No	Inorganics	-		0.0400	C	0.0130	C	1.0000	0.0010	38.0000	1.0000	Yes	-	2.7495	4.1864	-	-	-	243000.0000	1370000.0000	207000.0000	5030000.0000	2090000.0000	1480000.0000	2.07E+05nc
Lithium	7439-93-2	No	No	Inorganics	-		0.0020	P	-		1.0000	0.0010	6.9400	1.0000	Yes	-	0.1375	0.2093	-	-	-	12200.0000	68700.0000	10300.0000	251000.0000	105000.0000	73900.0000	1.03E+04nc
Mercuric Chloride	7487-94-7	No	No	Inorganics	-		0.0003	I	0.0003	G	0.0700	0.0010	271.5000	1.0000	Yes	-	0.0014	0.0022	-	-	-	1830.0000	722.0000	517.0000	37700.0000	1100.0000	1070.0000	5.17E+02nc
Molybdenum	7439-98-7	No	No	Inorganics	-		0.0050	I	0.0020	A	1.0000	0.0010	95.9400	1.0000	Yes	-	0.3437	0.5233	-	-	-	30400.0000	172000.0000	25800.0000	629000.0000	262000.0000	185000.0000	2.58E+04nc
Selenium	7782-49-2	No	No	Inorganics	-		0.0050	I	0.0200	C	1.0000	0.0010	78.9600	1.0000	Yes	-	0.3437	0.5233	-	-	-	30400.0000	172000.0000	25800.0000	629000.0000	262000.0000	185000.0000	2.58E+04nc
Thallium (Soluble Salts)	7440-28-0	No	No	Inorganics	-		0.0000	X	-		1.0000	0.0010	204.3800	1.0000	Yes	-	0.0007	0.0010	-	-	-	60.8000	344.0000	51.7000	1260.0000	523.0000	369.0000	5.17E+01nc

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TABLE A-3
HUMAN HEALTH EXPOSURE PARAMETERS FOR DERIVATION OF RISK BASED SCREENING LEVELS (RBSLs) - RECREATIONAL SURFACE WATER

Exposure Parameter		Units	Current/Future Off-Site Recreational Swimmer				Current/Future Off-Site Recreational Wader				Current/Future Off-Site Recreational Boater
			Child (Age <6)	Adolescent (6-<16 years)	Adult	Child, Adolescent and Adult (Ages 1 - 26)	Child (Age <6)	Adolescent (6-<16 years)	Adult	Child, Adolescent and Adult (Ages 1 - 26)	Adult
Standard Parameters											
Body Weight	BW	kg	15 USEPA, 2011 [1]	44 USEPA, 2011 [1]	80 USEPA, 2014a	NA	15 USEPA, 2011 [1]	44 USEPA, 2011 [1]	80 USEPA, 2014a	NA	80 USEPA, 2014a
Exposure Duration	ED	years	6 Ages <6	10 Ages 6 - <16	10 Balance of 26-yr exposure	26	6 Ages <6	10 Ages 6 - <16	10 Balance of 26-yr exposure	26	10 Balance of 26-yr exposure
Non–carcinogenic Averaging Time	Atnc	days	2190 ED expressed in days	3650 ED expressed in days	3650 ED expressed in days	9490 ED expressed in days	2190 ED expressed in days	3650 ED expressed in days	3650 ED expressed in days	9490 ED expressed in days	3650 ED expressed in days
Carcinogenic Averaging Time	Atc	days	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime	25550 70 year lifetime
Incidental Ingestion of Surface Water											
Exposure Frequency	EF	days/year	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	NA
Water Ingestion Rate	IR	L/day	0.10 USEPA, 2014b [2]	0.10 USEPA, 2014b [2]	0.10 USEPA, 2014b [2]	NA	0.10 USEPA, 2014b [2]	0.02 USEPA, 2014b [2]	0.02 USEPA, 2014b [2]	NA	NA
Fraction Ingested	FI	unitless	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	1.0 Assumption	NA
Age-Adjusted Water Ingestion Factor	IFWadj	L/kg	NA	NA	NA	3.39	NA	NA	NA	2.12	NA
Age-Adjusted Water Ingestion Factor-Mutagenic	IFWM	L/kg	NA	NA	NA	13.23	NA	NA	NA	10.33	NA
Dermal Exposure with Surface Water											
Exposure Frequency	EF	days/year	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b	45 USEPA, 2014b
Exposed Skin Surface Area	SA	cm^2	6365 USEPA, 2014a	13350 USEPA, 2011 [3]	19652 USEPA, 2014a	NA	1770 USEPA, 2011 [4]	3820 USEPA, 2011 [4]	5790 USEPA, 2011 [4]	NA	5790 USEPA, 2011 [4]
Exposure Time	t-event	hr/event	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific [5]	2 Site-specific	2 Site-specific [5]
Events per Day	EV	event/day	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific [5]	1.0 Site-specific	1 Site-specific [5]
Age-Adjusted Dermal Contact Factor	DFWadj	events-cm^2/kg	NA	NA	NA	361647	NA	NA	NA	103497	NA
Age-Adjusted Dermal Contact Factor-Mutagenic	DFWM	events-cm^2/kg	NA	NA	NA	1131185	NA	NA	NA	319693	NA

NOTES AND ABBREVIATIONS

USEPA, 2002 - Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OWSWER 9355.4-24
USEPA, 2011 - Exposure Factors Handbook. USEPA/600/R-10/030. October, 2011.
USEPA, 2014a - Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.1-120. February 6, 2014.
USEPA, 2014b - Region 4 Human Health Risk Assessment Supplemental Guidance. January 2014. Draft Final.
[1] - Table 8-1 of USEPA (2011).
[2] - Ingestion rate of 50 ml/hour of surface water is used for exposures to water during swimming. Intake rates for exposure to surface water during wading are 50 ml/hour for children 1-6, and 10 ml/hour for adolescents and adults.
The water ingestion rate in liters/day is calculated as follows: ingestion (ml/hr) x exposure time (hr/event)/1000 (ml/L).
[3] - Based on weighted average of mean values for 6-<16 years.
[4] - Based on surface area of hands, forearms, lower legs, and feet.
[5] - Assumes 2 hours per event and that on days when recreation in water occurs, all daily exposure to water is derived from locations at the Site.

Values based on a time-weighted average of child, adolescent, and adult exposure values are calculated as follows:
Water
IFWadj = (child ED [0-2] x child EF [0-2] x child IR [0-2] / child BW [0-2]) + (child ED [2-6] x child EF [2-6] x child IR [2-6] / child BW [2-6]) + (older child ED [6-16] x older child EF [6-16] x older child IR [6-16] / older child BW [6-16]) + (adult ED x adult EF x adult IR / adult BW)
DFWadj = (child EF [0-2] x child ED [0-2] x child SA [0-2] x child EV [0-2] / child BW [0-2]) + (child EF [2-6] x child ED [2-6] x child SA [2-6] x child EV [2-6] / child BW [2-6]) + (older child EF [6-16] x older child ED [6-16] x older child SA [6-16] x older child EV [6-16] / older child BW [6-16]) + (adult EF x adult ED x adult SA x adult EV / adult BW)
Water - mutagenic
IFWM = (child ED [0-2] x child EF [0-2] x child IR [0-2] x ADAF [0-2] / child BW [0-2]) + (child ED [2-6] x child EF [2-6] x child IR [2-6] x ADAF [2-6] / child BW [2-6]) + (older child ED [6-16] x child EF [6-16] x older child IR [6-16] x ADAF [6-16] / older child BW [6-16]) + (adult ED x adult EF x adult IR x adult ADAF / adult BW)
DFWM = (child EF [0-2] x child ED [0-2] x child SA [0-2] x child EV [0-2] x ADAF [0-2] / child BW [0-2]) + (child EF [2-6] x child ED [2-6] x child SA [2-6] x child EV [2-6] x ADAF [2-6] / child BW [2-6]) + (older child EF [6-16] x older child ED [6-16] x older child SA [6-16] x older child EV [6-16] x ADAF [6-16] / older child BW [6-16]) +
(adult EF x adult ED x adult SA x adult EV x adult ADAF / adult BW)

USEPA guidance for early life exposure to carcinogens (USEPA, 2005) requires that risks for potentially carcinogenic constituents that are presumed to act by a mutagenic mode of action be calculated differently than for constituents that do not act via a mutagenic mode of action.
Therefore, the age-dependent adjustment factors (ADAF) will be applied for calculations involving children under the age of 16. The ADAFs are as follows:
Age 0 to 2 years (2 year interval from birth until 2nd birthday) – ADAF = 10
Ages 2 to 16 years (14 year interval from 2nd birthday to 16th birthday) – ADAF = 3
Ages 16 and up (after 16th birthday) – no adjustment - ADAF = 1
The exposure parameters for children ages <6 are applied to children 0 - 2 and 2- 6.

Current/Future Off-Site Recreational Boater

Site-specific
Recreator Surface Water Inputs
/HTML"Output to Spreadsheet

Variable	Recreator Surface Water Default Value	Form-input Value
BW_{0-2} (body weight) kg	15	0
BW_{2-6} (body weight) kg	15	0
BW_{6-16} (body weight) kg	80	0
BW_{16-30} (body weight) kg	80	80
BW_{a} (body weight - adult) kg	80	80
BW_{rec-a} (body weight - adult) kg	80	80
$DFW_{rec-adj}$ (age-adjusted dermal factor) cm^2-event/kg	0	32568.75
$DFWM_{rec-adj}$ (mutagenic age-adjusted dermal factor) cm^2-event/kg	0	32568.75
ED_{rec} (exposure duration - recreator) years	26	10
ED_{0-2} (exposure duration) years	2	0
ED_{2-6} (exposure duration) years	4	0
ED_{6-16} (exposure duration) years	10	0
ED_{16-30} (exposure duration) years	10	10
ED_{rec-a} (exposure duration - adult) years	20	10
EF_{rec-w} (exposure frequency) days/year	0	45
EF_{2-6} (exposure frequency) days/year	0	0
EF_{6-16} (exposure frequency) days/year	0	0
EF_{16-30} (exposure frequency) days/year	0	45
EF_{rec-a} (adult exposure frequency) days/year	0	45
ET_{0-2} (exposure time) hours/event	0	0
ET_{2-6} (exposure time) hours/event	0	0
ET_{6-16} (exposure time) hours/event	0	0
ET_{16-30} (exposure time) hours/event	0	2
ET_{rec-a} (adult exposure time) hours/event	0	2
EV_{0-2} (events) events/day	0	0
EV_{2-6} (events) events/day	0	0
EV_{6-16} (events) events/day	0	0
EV_{16-30} (events) events/day	0	1
EV_{rec-a} (adult) events/day	0	1
THQ (target hazard quotient) unitless	0.1	1
$IFW_{rec-adj}$ (age-adjusted water intake rate) L/kg	0	0
$IFWM_{rec-adj}$ (mutagenic age-adjusted water intake rate) L/kg	0	0
IRW_{0-2} (water intake rate) L/hour	0.12	0
IRW_{2-6} (water intake rate) L/hour	0.12	0
IRW_{6-16} (water intake rate) L/hour	0.124	0
IRW_{16-30} (water intake rate) L/hour	0.0985	0
IRW_{rec} (water intake rate - adult) L/day	0.11	0
IRW_{rec-a} (water intake rate - adult) L/hr	0.11	0
LT (lifetime - recreator) years	70	70
SA_{0-2} (skin surface area) cm^2	6365	0
SA_{2-6} (skin surface area) cm^2	6365	0
SA_{6-16} (skin surface area) cm^2	19652	0
SA_{16-30} (skin surface area) cm^2	19652	5790
SA_{rec} (skin surface area - adult) cm^2	19652	5790
SA_{rec-a} (skin surface area - adult) cm^2	19652	5790
Apparent thickness of stratum corneum (cm)	0.001	0.001
TR (target risk) unitless	0.000001	0.00001

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Site-specific

Recreator Regional Screening Levels (RSL) for Surface Water

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o(mg/kg-day)$^{-1}$	SF_oRef	RfD (mg/kg-day)	RfD Ref	RfC (mg/m^3)	RfC Ref	RAGSe GIABS (unitless)	K_p (cm/hr)	MW	FA (unitless)	In EPD?	$DA_{event (ca)}$	$DA_{event (nc child)}$	$DA_{event (nc adult)}$	Ingestion SL TR=1E-05 (ug/L)	Dermal SL TR=1E-05 (ug/L)	Carcinogenic SL TR=1E-05 (ug/L)	Ingestion SL (Child) THQ=1 (ug/L)	Dermal SL (Child) THQ=1 (ug/L)	Noncarcinogenic SL (Child) THQ=1 (ug/L)	Ingestion SL (Adult) THQ=1 (ug/L)	Dermal SL (Adult) THQ=1 (ug/L)	Noncarcinogenic SL (Adult) THQ=1 (ug/L)	Screening Level (ug/L)
Antimony (metallic)	7440-36-0	No	No	Inorganics	-		4.00E-04	I	3.00E-04	A	1.50E-01	1.00E-03	1.22E+02	1.00E+00	Yes	-	-	6.72E-03	-	-	-	-	-	-	-	3.36E+03	3.36E+03	3.36E+03 nc
Arsenic, Inorganic	7440-38-2	No	No	Inorganics	1.50E+00	I	3.00E-04	I	1.50E-05	C	1.00E+00	1.00E-03	7.49E+01	1.00E+00	Yes	5.23E-03	-	3.36E-02	-	2.61E+03	2.61E+03	-	-	-	-	1.68E+04	1.68E+04	2.61E+03 ca
Barium	7440-39-3	No	No	Inorganics	-		2.00E-01	I	5.00E-04	H	7.00E-02	1.00E-03	1.37E+02	1.00E+00	Yes	-	-	1.57E+00	-	-	-	-	-	-	-	7.84E+05	7.84E+05	7.84E+05 nc
Beryllium and compounds	7440-41-7	No	No	Inorganics	-		2.00E-03	I	2.00E-05	I	7.00E-03	1.00E-03	9.01E+00	1.00E+00	Yes	-	-	1.57E-03	-	-	-	-	-	-	-	7.84E+02	7.84E+02	7.84E+02 nc
Boron And Borates Only	7440-42-8	No	No	Inorganics	-		2.00E-01	I	2.00E-02	H	1.00E+00	1.00E-03	1.38E+01	1.00E+00	Yes	-	-	2.24E+01	-	-	-	-	-	-	-	1.12E+07	1.12E+07	1.12E+07 nc
Cadmium (Water)	7440-43-9	No	No	Inorganics	-		5.00E-04	I	1.00E-05	A	5.00E-02	1.00E-03	1.12E+02	1.00E+00	Yes	-	-	2.80E-03	-	-	-	-	-	-	-	1.40E+03	1.40E+03	1.40E+03 nc
Chromium(III), Insoluble Salts	16065-83-1	No	No	Inorganics	-		1.50E+00	I	-		1.30E-02	1.00E-03	5.20E+01	1.00E+00	Yes	-	-	2.19E+00	-	-	-	-	-	-	-	1.09E+06	1.09E+06	1.09E+06 nc
Cobalt	7440-48-4	No	No	Inorganics	-		3.00E-04	P	6.00E-06	P	1.00E+00	4.00E-04	5.89E+01	1.00E+00	Yes	-	-	3.36E-02	-	-	-	-	-	-	-	4.20E+04	4.20E+04	4.20E+04 nc
Fluoride	16984-48-8	No	No	Inorganics	-		4.00E-02	C	1.30E-02	C	1.00E+00	1.00E-03	3.80E+01	1.00E+00	Yes	-	-	4.48E+00	-	-	-	-	-	-	-	2.24E+06	2.24E+06	2.24E+06 nc
Lithium	7439-93-2	No	No	Inorganics	-		2.00E-03	P	-		1.00E+00	1.00E-03	6.94E+00	1.00E+00	Yes	-	-	2.24E-01	-	-	-	-	-	-	-	1.12E+05	1.12E+05	1.12E+05 nc
Mercuric Chloride	7487-94-7	No	No	Inorganics	-		3.00E-04	I	3.00E-04	G	7.00E-02	1.00E-03	2.72E+02	1.00E+00	Yes	-	-	2.35E-03	-	-	-	-	-	-	-	1.18E+03	1.18E+03	1.18E+03 nc
Molybdenum	7439-98-7	No	No	Inorganics	-		5.00E-03	I	2.00E-03	A	1.00E+00	1.00E-03	9.59E+01	1.00E+00	Yes	-	-	5.60E-01	-	-	-	-	-	-	-	2.80E+05	2.80E+05	2.80E+05 nc
Selenium	7782-49-2	No	No	Inorganics	-		5.00E-03	I	2.00E-02	C	1.00E+00	1.00E-03	7.90E+01	1.00E+00	Yes	-	-	5.60E-01	-	-	-	-	-	-	-	2.80E+05	2.80E+05	2.80E+05 nc
Thallium (Soluble Salts)	7440-28-0	No	No	Inorganics	-		1.00E-05	X	-		1.00E+00	1.00E-03	2.04E+02	1.00E+00	Yes	-	-	1.12E-03	-	-	-	-	-	-	-	5.60E+02	5.60E+02	5.60E+02 nc

Output generated 10DEC2020:12:50:07

Current/Future Off-Site Recreational Swimmer

Site-specific

Recreator Surface Water Inputs

/HTML"Output to Spreadsheet

Variable	Recreator Surface Water Default Value	Form-input Value
BW_{0-2} (body weight) kg	15	15
BW_{2-6} (body weight) kg	15	15
BW_{6-16} (body weight) kg	80	44
BW_{16-30} (body weight) kg	80	80
BW_{a} (body weight - adult) kg	80	62
BW_{rec-a} (body weight - adult) kg	80	62
$DFW_{rec-adj}$ (age-adjusted dermal factor) cm^2-event/kg	0	354100.645
$DFWM_{rec-adj}$ (mutagenic age-adjusted dermal factor) cm^2-event/kg	0	1131184.77
ED_{rec} (exposure duration - recreator) years	26	26
ED_{0-2} (exposure duration) years	2	2
ED_{2-6} (exposure duration) years	4	4
ED_{6-16} (exposure duration) years	10	10
ED_{16-30} (exposure duration) years	10	10
ED_{rec-a} (exposure duration - adult) years	20	20
EF_{rec-w} (exposure frequency) days/year	0	45
EF_{2-6} (exposure frequency) days/year	0	45
EF_{6-16} (exposure frequency) days/year	0	45
EF_{16-30} (exposure frequency) days/year	0	45
EF_{rec-a} (adult exposure frequency) days/year	0	45
ET_{0-2} (exposure time) hours/event	0	2
ET_{2-6} (exposure time) hours/event	0	2
ET_{6-16} (exposure time) hours/event	0	2
ET_{16-30} (exposure time) hours/event	0	2
ET_{rec-a} (adult exposure time) hours/event	0	2
EV_{0-2} (events) events/day	0	1
EV_{2-6} (events) events/day	0	1
EV_{6-16} (events) events/day	0	1
EV_{16-30} (events) events/day	0	1
EV_{rec-a} (adult) events/day	0	1
THQ (target hazard quotient) unitless	0.1	1
$IFW_{rec-adj}$ (age-adjusted water intake rate) L/kg	0	6.503
$IFWM_{rec-adj}$ (mutagenic age-adjusted water intake rate) L/kg	0	26.461
IRW_{0-2} (water intake rate) L/hour	0.12	0.1
IRW_{2-6} (water intake rate) L/hour	0.12	0.1
IRW_{6-16} (water intake rate) L/hour	0.124	0.1
IRW_{16-30} (water intake rate) L/hour	0.0985	0.1
IRW_{rec} (water intake rate - adult) L/day	0.11	0.1
IRW_{rec-a} (water intake rate - adult) L/hr	0.11	0.1
LT (lifetime - recreator) years	70	70
SA_{0-2} (skin surface area) cm^2	6365	6365
SA_{2-6} (skin surface area) cm^2	6365	6365
SA_{6-16} (skin surface area) cm^2	19652	13350
SA_{16-30} (skin surface area) cm^2	19652	19652
SA_{rec} (skin surface area - adult) cm^2	19652	16501
SA_{rec-a} (skin surface area - adult) cm^2	19652	16501
Apparent thickness of stratum corneum (cm)	0.001	0.001
TR (target risk) unitless	0.000001	0.00001

Output generated 10DEC2020:12:38:41

Site-specific

Recreator Regional Screening Levels (RSL) for Surface Water

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o(mg/kg-day)$^{-1}$	SF_oRef	RfD (mg/kg-day)	RfD Ref	RfC (mg/m^3)	RfC Ref	RAGSe GIABS (unitless)	K_p (cm/hr)	MW	FA (unitless)	In EPD?	$DA_{event (ca)}$	$DA_{event (nc child)}$	$DA_{event (nc adult)}$	Ingestion SL TR=1E-05 (ug/L)	Dermal SL TR=1E-05 (ug/L)	Carcinogenic SL TR=1E-05 (ug/L)	Ingestion SL (Child) THQ=1 (ug/L)	Dermal SL (Child) THQ=1 (ug/L)	Noncarcinogenic SL (Child) THQ=1 (ug/L)	Ingestion SL (Adult) THQ=1 (ug/L)	Dermal SL (Adult) THQ=1 (ug/L)	Noncarcinogenic SL (Adult) THQ=1 (ug/L)	Screening Level (ug/L)
Antimony (metallic)	7440-36-0	No	No	Inorganics	-		4.00E-04	I	3.00E-04	A	1.50E-01	1.00E-03	1.22E+02	1.00E+00	Yes	-	1.15E-03	1.83E-03	-	-	-	2.43E+02	5.73E+02	1.71E+02	1.01E+03	9.14E+02	4.79E+02	1.71E+02 nc
Arsenic, Inorganic	7440-38-2	No	No	Inorganics	1.50E+00	I	3.00E-04	I	1.50E-05	C	1.00E+00	1.00E-03	7.49E+01	1.00E+00	Yes	4.81E-04	5.73E-03	9.14E-03	2.62E+01	2.41E+02	2.36E+01	1.83E+02	2.87E+03	1.72E+02	7.54E+02	4.57E+03	6.47E+02	2.36E+01 ca
Barium	7440-39-3	No	No	Inorganics	-		2.00E-01	I	5.00E-04	H	7.00E-02	1.00E-03	1.37E+02	1.00E+00	Yes	-	2.68E-01	4.27E-01	-	-	-	1.22E+05	1.34E+05	6.37E+04	5.03E+05	2.13E+05	1.50E+05	6.37E+04 nc
Beryllium and compounds	7440-41-7	No	No	Inorganics	-		2.00E-03	I	2.00E-05	I	7.00E-03	1.00E-03	9.01E+00	1.00E+00	Yes	-	2.68E-04	4.27E-04	-	-	-	1.22E+03	1.34E+02	1.21E+02	5.03E+03	2.13E+02	2.05E+02	1.21E+02 nc
Boron And Borates Only	7440-42-8	No	No	Inorganics	-		2.00E-01	I	2.00E-02	H	1.00E+00	1.00E-03	1.38E+01	1.00E+00	Yes	-	3.82E+00	6.10E+00	-	-	-	1.22E+05	1.91E+06	1.14E+05	5.03E+05	3.05E+06	4.32E+05	1.14E+05 nc
Cadmium (Water)	7440-43-9	No	No	Inorganics	-		5.00E-04	I	1.00E-05	A	5.00E-02	1.00E-03	1.12E+02	1.00E+00	Yes	-	4.78E-04	7.62E-04	-	-	-	3.04E+02	2.39E+02	1.34E+02	1.26E+03	3.81E+02	2.92E+02	1.34E+02 nc
Chromium(III), Insoluble Salts	16065-83-1	No	No	Inorganics	-		1.50E+00	I	-		1.30E-02	1.00E-03	5.20E+01	1.00E+00	Yes	-	3.73E-01	5.94E-01	-	-	-	9.13E+05	1.86E+05	1.55E+05	3.77E+06	2.97E+05	2.75E+05	1.55E+05 nc
Cobalt	7440-48-4	No	No	Inorganics	-		3.00E-04	P	6.00E-06	P	1.00E+00	4.00E-04	5.89E+01	1.00E+00	Yes	-	5.73E-03	9.14E-03	-	-	-	1.83E+02	7.17E+03	1.78E+02	7.54E+02	1.14E+04	7.08E+02	1.78E+02 nc
Fluoride	16984-48-8	No	No	Inorganics	-		4.00E-02	C	1.30E-02	C	1.00E+00	1.00E-03	3.80E+01	1.00E+00	Yes	-	7.65E-01	1.22E+00	-	-	-	2.43E+04	3.82E+05	2.29E+04	1.01E+05	6.10E+05	8.63E+04	2.29E+04 nc
Lithium	7439-93-2	No	No	Inorganics	-		2.00E-03	P	-		1.00E+00	1.00E-03	6.94E+00	1.00E+00	Yes	-	3.82E-02	6.10E-02	-	-	-	1.22E+03	1.91E+04	1.14E+03	5.03E+03	3.05E+04	4.32E+03	1.14E+03 nc
Mercuric Chloride	7487-94-7	No	No	Inorganics	-		3.00E-04	I	3.00E-04	G	7.00E-02	1.00E-03	2.72E+02	1.00E+00	Yes	-	4.01E-04	6.40E-04	-	-	-	1.83E+02	2.01E+02	9.56E+01	7.54E+02	3.20E+02	2.25E+02	9.56E+01 nc
Molybdenum	7439-98-7	No	No	Inorganics	-		5.00E-03	I	2.00E-03	A	1.00E+00	1.00E-03	9.59E+01	1.00E+00	Yes	-	9.56E-02	1.52E-01	-	-	-	3.04E+03	4.78E+04	2.86E+03	1.26E+04	7.62E+04	1.08E+04	2.86E+03 nc
Selenium	7782-49-2	No	No	Inorganics	-		5.00E-03	I	2.00E-02	C	1.00E+00	1.00E-03	7.90E+01	1.00E+00	Yes	-	9.56E-02	1.52E-01	-	-	-	3.04E+03	4.78E+04	2.86E+03	1.26E+04	7.62E+04	1.08E+04	2.86E+03 nc
Thallium (Soluble Salts)	7440-28-0	No	No	Inorganics	-		1.00E-05	X	-		1.00E+00	1.00E-03	2.04E+02	1.00E+00	Yes	-	1.91E-04	3.05E-04	-	-	-	6.08E+00	9.56E+01	5.72E+00	2.51E+01	1.52E+02	2.16E+01	5.72E+00 nc

Output generated 10DEC2020:12:38:41

Current/Future Off-Site Recreational Wader

Site-specific

Recreator Surface Water Inputs

/HTML"Output to Spreadsheet

Variable	Recreator Surface Water Default Value	Form-input Value
BW_{0-2} (body weight) kg	15	15
BW_{2-6} (body weight) kg	15	15
BW_{6-16} (body weight) kg	80	44
BW_{16-30} (body weight) kg	80	80
BW_a (body weight - adult) kg	80	62
BW_{rec-a} (body weight - adult) kg	80	62
$DFW_{rec-adj}$ (age-adjusted dermal factor) cm^2-event/kg	0	101610
$DFWM_{rec-adj}$ (mutagenic age-adjusted dermal factor) cm^2-event/kg	0	319693.295
ED_{rec} (exposure duration - recreator) years	26	26
ED_{0-2} (exposure duration) years	2	2
ED_{2-6} (exposure duration) years	4	4
ED_{6-16} (exposure duration) years	10	10
ED_{16-30} (exposure duration) years	10	10
ED_{rec-a} (exposure duration - adult) years	20	20
EF_{rec-w} (exposure frequency) days/year	0	45
EF_{2-6} (exposure frequency) days/year	0	45
EF_{6-16} (exposure frequency) days/year	0	45
EF_{16-30} (exposure frequency) days/year	0	45
EF_{rec-a} (adult exposure frequency) days/year	0	45
ET_{0-2} (exposure time) hours/event	0	2
ET_{2-6} (exposure time) hours/event	0	2
ET_{6-16} (exposure time) hours/event	0	2
ET_{16-30} (exposure time) hours/event	0	2
ET_{rec-a} (adult exposure time) hours/event	0	2
EV_{0-2} (events) events/day	0	1
EV_{2-6} (events) events/day	0	1
EV_{6-16} (events) events/day	0	1
EV_{16-30} (events) events/day	0	1
EV_{rec-a} (adult) events/day	0	1
THQ (target hazard quotient) unitless	0.1	1
$IFW_{rec-adj}$ (age-adjusted water intake rate) L/kg	0	4.181
$IFWM_{rec-adj}$ (mutagenic age-adjusted water intake rate) L/kg	0	20.652
IRW_{0-2} (water intake rate) L/hour	0.12	0.1
IRW_{2-6} (water intake rate) L/hour	0.12	0.1
IRW_{6-16} (water intake rate) L/hour	0.124	0.02
IRW_{16-30} (water intake rate) L/hour	0.0985	0.02
IRW_{rec} (water intake rate - adult) L/day	0.11	0.02
IRW_{rec-a} (water intake rate - adult) L/hr	0.11	0.02
LT (lifetime - recreator) years	70	70
SA_{0-2} (skin surface area) cm^2	6365	1770
SA_{2-6} (skin surface area) cm^2	6365	1770
SA_{6-16} (skin surface area) cm^2	19652	3820
SA_{16-30} (skin surface area) cm^2	19652	5790
SA_{rec} (skin surface area - adult) cm^2	19652	4805
SA_{rec-a} (skin surface area - adult) cm^2	19652	4805
Apparent thickness of stratum corneum (cm)	0.001	0.001
TR (target risk) unitless	0.000001	0.00001

Output generated 10DEC2020:12:45:04

Site-specific

Recreator Regional Screening Levels (RSL) for Surface Water

Key: I = IRIS; P = PPRTV; O = OPP; A = ATSDR; C = Cal EPA; X = PPRTV Screening Level; H = HEAST; D = DWSHA; W = TEF applied; E = RPF applied; G = see user's guide; U = user provided; ca = cancer; nc = noncancer; * = where: nc SL < 100X ca SL; ** = where nc SL < 10X ca SL; SSL values are based on DAF=1; max = ceiling limit exceeded; sat = Csat exceeded.

Chemical	CAS Number	Mutagen?	Volatile?	Chemical Type	SF_o(mg/kg-day)$^{-1}$	SF_oRef	RfD (mg/kg-day)	RfD Ref	RfC (mg/m^3)	RfC Ref	RAGSe GIABS (unitless)	K_p (cm/hr)	MW	FA (unitless)	In EPD?	$DA_{event\ (ca)}$	$DA_{event\ (nc\ child)}$	$DA_{event\ (nc\ adult)}$	Ingestion SL TR=1E-05 (ug/L)	Dermal SL TR=1E-05 (ug/L)	Carcinogenic SL TR=1E-05 (ug/L)	Ingestion SL (Child) THQ=1 (ug/L)	Dermal SL (Child) THQ=1 (ug/L)	Noncarcinogenic SL (Child) THQ=1 (ug/L)	Ingestion SL (Adult) THQ=1 (ug/L)	Dermal SL (Adult) THQ=1 (ug/L)	Noncarcinogenic SL (Adult) THQ=1 (ug/L)	Screening Level (ug/L)
Antimony (metallic)	7440-36-0	No	No	Inorganics	-		4.00E-04	I	3.00E-04	A	1.50E-01	1.00E-03	1.22E+02	1.00E+00	Yes	-	4.12E-03	6.28E-03	-	-	-	2.43E+02	2.06E+03	2.18E+02	5.03E+03	3.14E+03	1.93E+03	2.18E+02 nc
Arsenic, Inorganic	7440-38-2	No	No	Inorganics	1.50E+00	I	3.00E-04	I	1.50E-05	C	1.00E+00	1.00E-03	7.49E+01	1.00E+00	Yes	1.68E-03	2.06E-02	3.14E-02	4.07E+01	8.38E+02	3.89E+01	1.83E+02	1.03E+04	1.79E+02	3.77E+03	1.57E+04	3.04E+03	3.89E+01 ca
Barium	7440-39-3	No	No	Inorganics	-		2.00E-01	I	5.00E-04	H	7.00E-02	1.00E-03	1.37E+02	1.00E+00	Yes	-	9.62E-01	1.47E+00	-	-	-	1.22E+05	4.81E+05	9.71E+04	2.51E+06	7.33E+05	5.67E+05	9.71E+04 nc
Beryllium and compounds	7440-41-7	No	No	Inorganics	-		2.00E-03	I	2.00E-05	I	7.00E-03	1.00E-03	9.01E+00	1.00E+00	Yes	-	9.62E-04	1.47E-03	-	-	-	1.22E+03	4.81E+02	3.45E+02	2.51E+04	7.33E+02	7.12E+02	3.45E+02 nc
Boron And Borates Only	7440-42-8	No	No	Inorganics	-		2.00E-01	I	2.00E-02	H	1.00E+00	1.00E-03	1.38E+01	1.00E+00	Yes	-	1.37E+01	2.09E+01	-	-	-	1.22E+05	6.87E+06	1.20E+05	2.51E+06	1.05E+07	2.03E+06	1.20E+05 nc
Cadmium (Water)	7440-43-9	No	No	Inorganics	-		5.00E-04	I	1.00E-05	A	5.00E-02	1.00E-03	1.12E+02	1.00E+00	Yes	-	1.72E-03	2.62E-03	-	-	-	3.04E+02	8.59E+02	2.25E+02	6.29E+03	1.31E+03	1.08E+03	2.25E+02 nc
Chromium(III), Insoluble Salts	16065-83-1	No	No	Inorganics	-		1.50E+00	I	-		1.30E-02	1.00E-03	5.20E+01	1.00E+00	Yes	-	1.34E+00	2.04E+00	-	-	-	9.13E+05	6.70E+05	3.86E+05	1.89E+07	1.02E+06	9.68E+05	3.86E+05 nc
Cobalt	7440-48-4	No	No	Inorganics	-		3.00E-04	P	6.00E-06	P	1.00E+00	4.00E-04	5.89E+01	1.00E+00	Yes	-	2.06E-02	3.14E-02	-	-	-	1.83E+02	2.58E+04	1.81E+02	3.77E+03	3.92E+04	3.44E+03	1.81E+02 nc
Fluoride	16984-48-8	No	No	Inorganics	-		4.00E-02	C	1.30E-02	C	1.00E+00	1.00E-03	3.80E+01	1.00E+00	Yes	-	2.75E+00	4.19E+00	-	-	-	2.43E+04	1.37E+06	2.39E+04	5.03E+05	2.09E+06	4.05E+05	2.39E+04 nc
Lithium	7439-93-2	No	No	Inorganics	-		2.00E-03	P	-		1.00E+00	1.00E-03	6.94E+00	1.00E+00	Yes	-	1.37E-01	2.09E-01	-	-	-	1.22E+03	6.87E+04	1.20E+03	2.51E+04	1.05E+05	2.03E+04	1.20E+03 nc
Mercuric Chloride	7487-94-7	No	No	Inorganics	-		3.00E-04	I	3.00E-04	G	7.00E-02	1.00E-03	2.72E+02	1.00E+00	Yes	-	1.44E-03	2.20E-03	-	-	-	1.83E+02	7.22E+02	1.46E+02	3.77E+03	1.10E+03	8.51E+02	1.46E+02 nc
Molybdenum	7439-98-7	No	No	Inorganics	-		5.00E-03	I	2.00E-03	A	1.00E+00	1.00E-03	9.59E+01	1.00E+00	Yes	-	3.44E-01	5.23E-01	-	-	-	3.04E+03	1.72E+05	2.99E+03	6.29E+04	2.62E+05	5.07E+04	2.99E+03 nc
Selenium	7782-49-2	No	No	Inorganics	-		5.00E-03	I	2.00E-02	C	1.00E+00	1.00E-03	7.90E+01	1.00E+00	Yes	-	3.44E-01	5.23E-01	-	-	-	3.04E+03	1.72E+05	2.99E+03	6.29E+04	2.62E+05	5.07E+04	2.99E+03 nc
Thallium (Soluble Salts)	7440-28-0	No	No	Inorganics	-		1.00E-05	X	-		1.00E+00	1.00E-03	2.04E+02	1.00E+00	Yes	-	6.87E-04	1.05E-03	-	-	-	6.08E+00	3.44E+02	5.98E+00	1.26E+02	5.23E+02	1.01E+02	5.98E+00 nc

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ATTACHMENT B

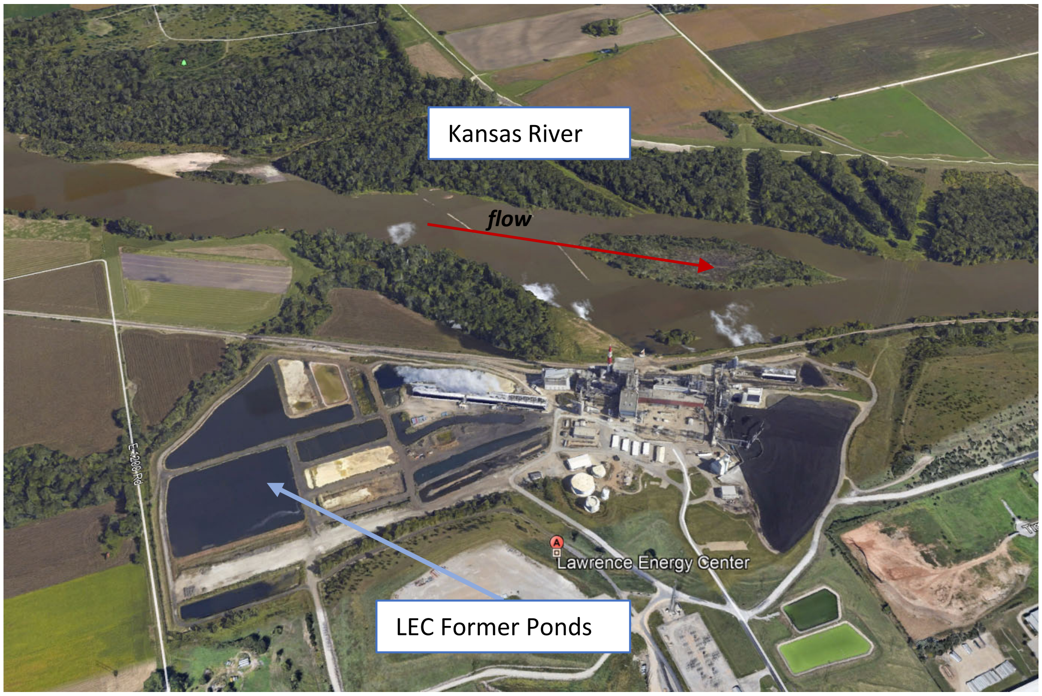
Surface Water Dilution Attenuation Factor

HALEY ALDRICH

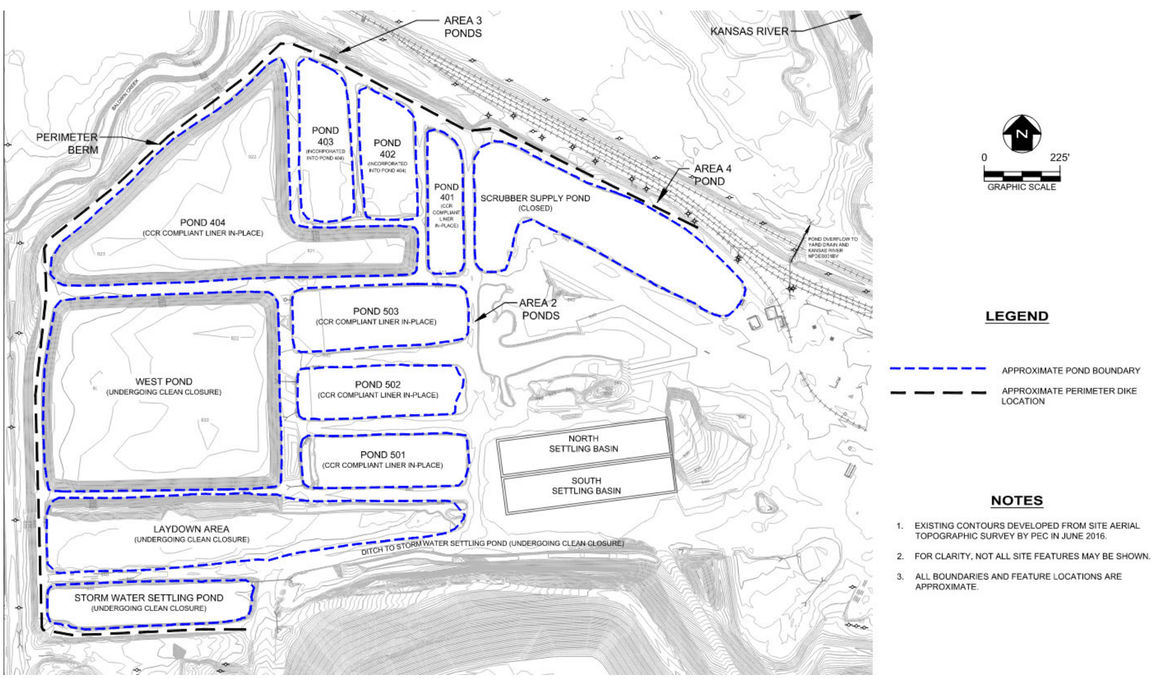
CALCULATIONS

Client	Evergy Kansas Central, Inc.
Project	Lawrence Energy Center
Subject	Dilution-Attenuation Factor Calculation

File No.	129778-043
Sheet	1 of 4
Date	09 December 2020
Computed By	Dimitri Quafisi
Checked By	



Google Earth Perspective View, Facing North



Former Pond Construction and Site Topography Prior to Closure,

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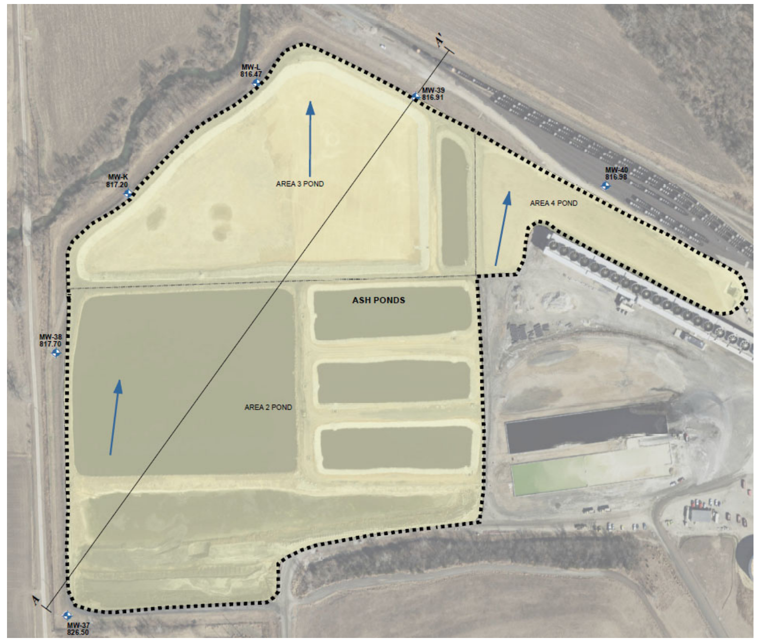
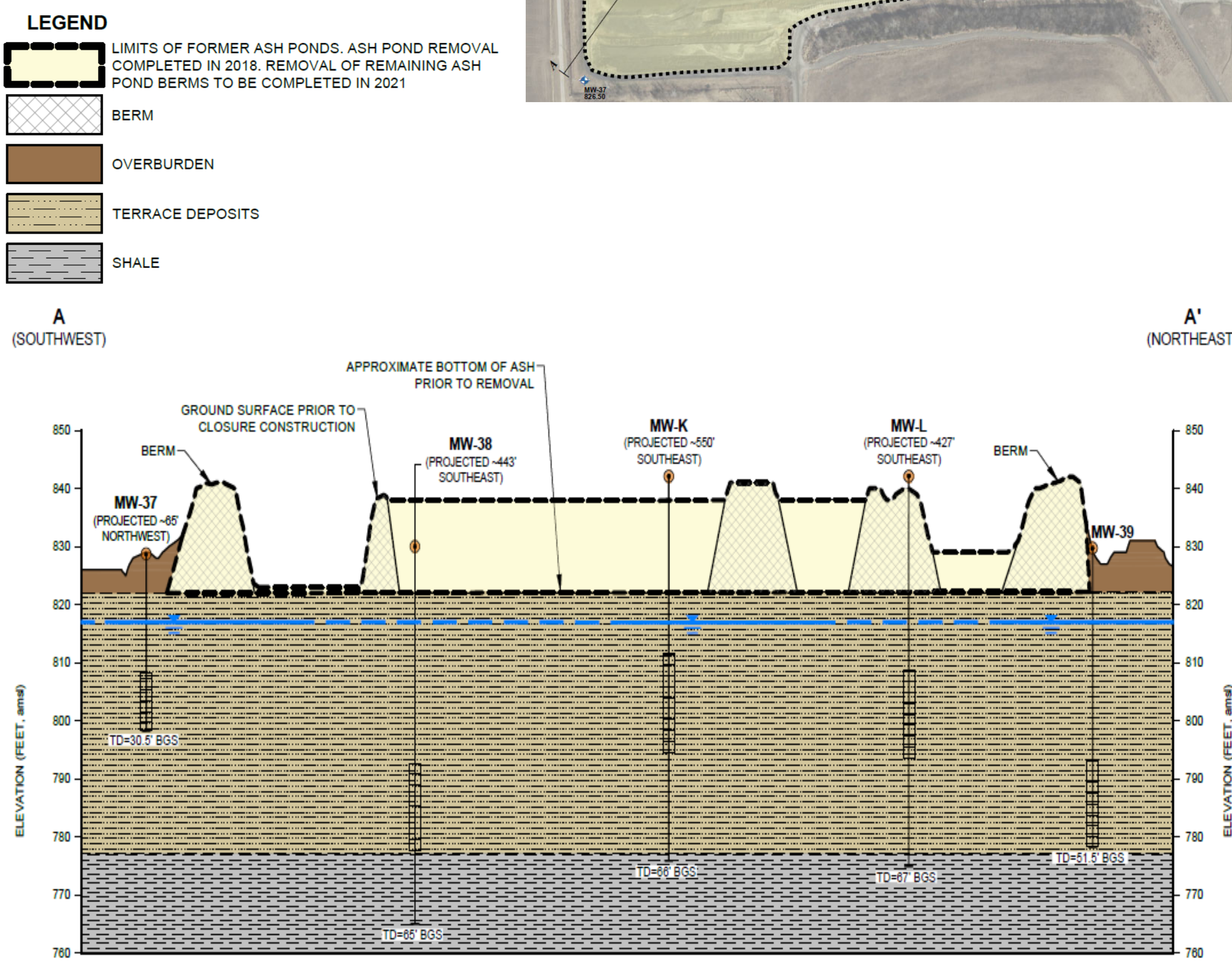
CALCULATIONS

Client	Evergy Kansas Central, Inc.	File No.	129778-043
Project	Lawrence Energy Center	Sheet	2 of 4
Subject	Dilution-Attenuation Factor Calculation	Date	09 December 2020
		Computed By	Dimitri Quafisi
		Checked By	

A Conceptual Model was developed for the LEC Ash Ponds using subsurface cross section interpretations from boring logs, and surveyed elevations and presented in the November 24th, 2020 CCR Groundwater Monitoring Network Description prepared by Haley and Aldrich, inc. Four basic subsurface units were identified: bedrock, fine grained overburden, terrace deposits, and coal-combustion residuals (CCR, or "ash") which was historically removed.

These units were utilized for groundwater calculations for the Site. The terrace deposit is the primary flow pathway at the Site.





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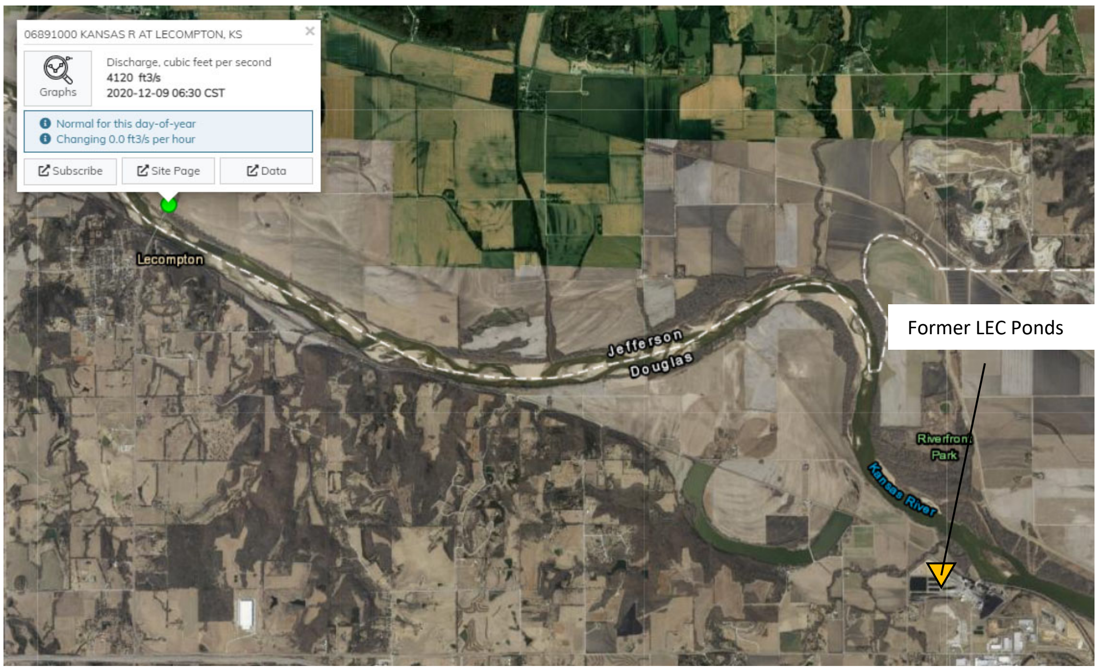
River discharge calculations were obtained from the Lecompton gauging station upstream of the Site. No observed dams or obstructions were identified between the gauging station and the Site.

River discharge data were obtained from the USGS gauging station near Lecompton KS, (Station 06891000 Kansas R At Lecompton, KS). Available data for the Site reported a historical low discharge of 199.7 ft3/sec over a 7-day period in 1956. To conservatively estimate the DAF for this location, this low flow rate was utilized.



SUMMARY STATISTICS

	Water Year 2019		Water Years 1937 - 2019	
Annual total	7,355,000			
Annual mean	20,150		7,087	
Highest annual mean			28,330	1993
Lowest annual mean			1,275	1956
Highest daily mean	90,200	Jun 24	472,000	Jul 13, 1951
Lowest daily mean	1,550	Oct 03	185.0	Oct 13, 1956
Annual 7-day minimum	3,521	Apr 18	199.7	Oct 08, 1956
Maximum peak flow			483,000[a]	Jul 13, 1951
Maximum peak stage			30.23	Jul 13, 1951
Annual runoff (cfsm)	0.345		0.121	
Annual runoff (inches)	4.68		1.65	
10 percent exceeds	45,340		17,200	
50 percent exceeds	15,500		3,290	
90 percent exceeds	5,380		1,000	

[a] Discharge affected by Regulation or Diversion

Lowest 7-day discharge statistics from 1956.

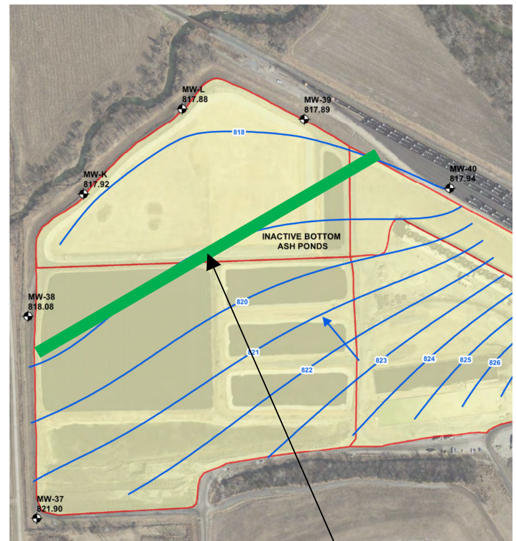
CALCULATIONS

Client	Evergy Kansas Central, Inc.	File No.	129778-043
Project	Lawrence Energy Center	Sheet	4 of 4
Subject	Dilution-Attenuation Factor Calculation	Date	09 December 2020
		Computed By	Dimitri Quafisi
		Checked By	

Scenario 1

•Typical measured values for site hydraulic conductivities (K), most conservative value for discharge of Kansas River

Unit	Horizontal K (cm/sec)	Horizontal K (ft/day)
Fine grained soils	1.8 x 10-6	0.0051
Terrace Deposits	1.5 x 10-3	4.25
Bedrock	1 x 10-6	0.00283



Cross-sectional Area Used for Calculations. Groundwater flow map from the November 19, 2018 gauging event.

Scenario 2

•Conservative (high) values for site hydraulic conductivities (K), most conservative value for discharge of Kansas River

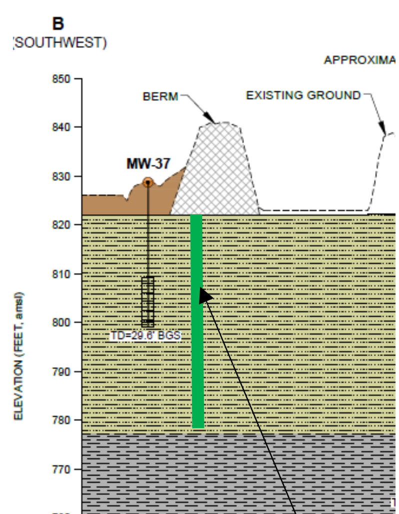
Unit	Horizontal K (cm/sec)	Horizontal K (ft/day)
Fine grained soils	1.8 x 10-6	0.0051
Terrace Deposits	4.2 x 10-3	11.91
Bedrock	1 x 10-6	0.00283

$$DAF = \frac{Q_R}{Q_G}$$

Where:

$Q_R =$ Discharge of Kansas River near LEC, at Low-Flow conditions.

$Q_G =$ Calculated Discharge from LEC Pond to Kansas River



Cross-sectional Thickness Used for Calculations. Assumes maximum thickness discharging to river.

Pond Elevation (feet)83,	Q_G(cf/day)	Q_R (cf/day)	DAF
Scenario 1	5,919.48	17,254,080	**2,915**
Scenario 2	16,808	17,254,080	**1,026**